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## THE UNIVERSITIES AND SCIENTIFIC MAN-POWER

ALTHOUGH the report of the Committee on Scientific Man-Power (see p. 794 of this issue) contains little that was not generally known to men of science themselves and to organisations responsible for training scientific workers or employing them in considerable numbers, the composition of this authoritative Committee lends weight to suggestions that have been freely canvassed in many quarters during the last few years. That many of its findings have already found expression—notably in a series of articles in the *Economist* last February—is indeed all to the good, and indicates how closely the recommendations of this report are in line with the trend of informed opinion. To the extent that the ground has in this way been so well prepared, it should be the easier to secure the action necessary to meet the basic challenge thrown down by this report to double the capacity of British universities, alike in respect of teaching and of research, within a decade. In detail some of its proposals are likely to encounter opposition, but the close reasoning of this lucid report should facilitate that task of educating opinion generally which will be required to secure the formulation and enactment of an appropriate policy.

On that ground alone it is important to note that the Committee, while placing on the universities of Britain the main responsibility for meeting the deficit in scientific man-power, has taken no narrow or materialistic view of the functions of the universities. Its members are well aware that the training of specialists is not the only, or even the most important, function of a university, and are confident that the universities themselves will strive to ensure that specialized knowledge is not bought at the expense of wisdom. Not only does the Committee repudiate any claim for preferential treatment for students of science in such matters as military service, but also it deprecates any attempt to meet the increased demand for scientific workers and technologists at the expense of other subjects, and its estimates for university expansion contemplate the expansion of the arts faculties simultaneously with that in the science side to give the required increased output of science graduates. In regard to the future demand for qualified scientific workers, it is far from holding that they should walk narrowly within their own subject ; though it is true that the wider diffusion of scientific knowledge and scientific methods will be promoted not merely by the employment of scientific men themselves in a wider range of administrative, managerial or other professional positions, but also and still more by the better teaching of science as an element in a general education at the secondary school or university level.

These general views on the purposes of university education will command general and unqualified assent. Some points of detail, however, are open to criticism. Thus the definition of 'qualified scientist' used in the report seems unduly narrow. To limit it to "persons holding degrees in the mathematical,

physical, chemical and biological sciences, together with the small number of men and women who without being university graduates, are members of recognized scientific institutions with a membership status that is accepted as the equivalent of a university degree", appears to be unnecessarily exclusive. In particular, it would leave out the engineer and thus err in the opposite direction to the Percy Report, which was excessively occupied with the engineering scientist. While the Barlow Committee welcomes the recommendations of the Percy Report, the omission of any estimates for the important studies in engineering and related technologies, which before the War accounted for roughly forty per cent as many university students as the pure science schools, is a serious weakness in this survey. In spite of the close relation between pure science and the various branches of engineering, the thinking and reasoning of the report appear to be somewhat confused at this point, and no guidance is given at all, except on the broadest possible ground, as to the question of university schools of engineering, to which Sir Ernest Simon has directed special attention.

The point might have passed unchallenged had the Committee adopted a wider definition of the term 'qualified scientist'; for apart from this discrimination against the engineer, the Committee has not attempted to deal with the separate needs for each category of scientific worker; and in considering university expansion, it has dealt with such expansion as a whole and not with that of individual faculties or schools. The statistical inquiry on which a reliable quantitative assessment of demand and supply for each branch of science must be based would have seriously delayed the presentation of the report. While the Committee may be right in holding that the determination of the demand for each particular type of scientific worker may safely be left for later attention, it is important that such inquiry should not be neglected. The report might well have included a firmer recommendation that such inquiry should be undertaken forthwith by a specific body, for example, if not by the Barlow Committee itself, then by the Appointments Department of the Ministry of Labour and National Service.

Such a recommendation would in fact be in keeping with those of the Hankey Committee on Higher Appointments; and its implementation, even if the report could not be expected for a year or two, might well assist to dispel any fears on the part of the universities that expansion of the order proposed in this report would leave them with excessive staffs and accommodation once supply had begun to approximate to demand. It would also be in keeping with the emphasis in this report on the importance of making the fullest use of the Appointments Department of the Ministry of Labour and National Service. It will be noted that, in recognizing that the value of this Department depends on its comprehensiveness, the Committee suggests that the universities themselves might find it of help in meeting their immediate need for an adequate supply of suitable teachers.

To the short-term problem of scientific man-power the report devotes little more than a passing glance, and what is said on the progress of demobilization is reassuring. The Committee does not believe that there is now any large number of qualified scientific workers still in the Forces, or that any significant number have had on demobilization to take employment in which their scientific qualifications are not adequately used. On the other hand, it passes rather lightly over the effect of military service, which the universities, at least in any estimates for a five-year expansion scheme, will have to regard as a permanent feature in framing policy and plans. It notes indeed that the effect of military service on a two years basis will mean that at any given time the equivalent of two years output of graduates will be diverted into the Forces, and its proposal that science students should be allowed, if they wish and if there is room for them, to complete their full course and obtain their degrees before doing their military service, is made in the interests of efficiency.

Mr. Isaacs' statement on military service made in the House of Commons shortly after the Barlow Report was published makes it more than ever important that the full implications of such a policy should be examined from the point of view of the most efficient use of man-power. On the grounds of such efficiency, as well as of social justice, it is imperative that the Government should remove as early as possible the large uncertainties which still attend the deferment of military service. Furthermore, the number of students who obtain deferment until they have completed their university courses will not be determined simply by the rules of the Ministry of Labour or by the proportion who prefer to enter the Forces before, rather than after, they go to a university. It may depend still more on the capacity of the universities to take new students, and on the vigour with which the proposals for university expansion are implemented and the necessary accommodation provided.

Here then are questions which have still to be answered before we can ensure the most effective use of the scientific man-power resources of Britain. But there are others also in the immediate problem, which the Committee has passed by, although it shows itself fully aware of the importance of securing the right conditions, such as adequate technical assistance and facilities, in order that the best use may be made of the qualified scientific worker. It is unfortunate that, through the timing of the report, it was apparently not possible to take account of the Minister's recent decision to reserve ninety per cent of places in the universities for those leaving the Forces. Nor does the question of re-training or refresher courses appear to have been considered as an immediate means of effectively mobilizing for peace-time tasks the numerous men and women of ability and intelligence who, both in the Forces and in the industries serving their needs, have been directed into scientific channels by war exigencies and at least partly equipped for a scientific career.

Examination of such factors as these would have strengthened the Committee's arguments in favour of university expansion, even if such measures might slightly reduce the period before supply begins to

overtake demand. It must be remembered, however, that the Lord President of the Council has repeatedly stated that he had impressed on the Committee the importance of an early report; and although there are directions in which inquiry has still to be pursued, the challenge which the report offers is inescapable. Moreover, the Government has already announced its general agreement with the conclusions of the Committee and that it is prepared to shoulder the considerable financial liability which the proposals involve. The Government hopes that they will receive the immediate and serious consideration of the university authorities, so that detailed proposals for giving effect to them can be formulated in consultation with the University Grants Committee.

In aggregate, the proposals for expansion are in line with those to be found in reports from the Parliamentary and Scientific Committee, the British Association Committee on Post-War University Education and the Association of Scientific Workers. In detail, they are strikingly similar to those advanced in an article in the *Economist* already mentioned; but it is clear that in some respects they go far beyond what particular universities have contemplated in their replies to the University Grants Committee. This is true not only of Oxford and Cambridge—the Committee goes so far as to exhort these universities that it is their duty to expand—but also of universities such as Leeds, where a student body of not less than 4,000 is suggested as the aim, in place of the 3,000 suggested by its vice-chancellor, Mr. Mouat Jones, last December.

What emerges from this analysis and programme presented by the Barlow Committee is in fact the necessity for finding the appropriate means of administering the large sums which the State will in future be called upon to provide for university education. The Barlow Committee is unanimously opposed to any infringement of the cherished independence of the universities, even if it could be justified on the ground that it would facilitate the execution of the programme of expansion. The survey, however, hints at some danger that that independence may hinder the formulation of a programme or plan of expansion at all; and it cannot be seriously contended that expenditure of large sums of public money, of the order of what may well reach forty million pounds a year, according to the estimate in the *Economist*, can be left entirely unplanned, and no attempt made to avoid duplication of schools for which students and adequate facilities could reasonably be expected at only one or two centres in Britain. Difficult as it may be, a means must therefore be found of giving any necessary guidance without encroaching on the traditional freedom of the universities, which to-day in a world in turmoil is of greater importance than ever.

It seems clear from the report and from Mr. Morrison's subsequent statement that the Government will continue to use the University Grants Committee as the chosen instrument for maintaining relations between the Government and the Universities of Britain. That in itself should amply guard the independence of the universities even when the University Grants Committee concerns itself more with positive university policy and is provided with stronger machinery and wider terms of reference. But the Barlow Committee, for all its reserve, touches on no more fundamental problem in an admirable report than this vital question of combining in a free society the independence of the universities, with all that it connotes of freedom of investigation and of teaching, with a wise direction of the money spent on them by the State. The report on Scientific Man-Power, if it has not said the last word on the subject and has left some questions to be probed further, at least indicates the first requirement: the creation forthwith of effective machinery for preparing a general plan of university development with generous Government financial support. Beyond this the Committee indicates concisely the further supporting measures required and problems to be solved: a greatly extended scholarship system, priorities for materials and labour for buildings, for equipment and for ancillary staff. The order of priorities indicated for the reconstruction period will not be questioned. Further, there will be general agreement on the need for relating the university building programme with the programmes for housing and for industrial and educational reconstruction, as well as for assessing the requirements of individual sciences and relating them to the existing capacity of the universities, to the demands of each other and to their associated technological services. Nor can the expansion of the humanistic faculties and other branches of learning be left entirely to trial and error, without grave danger of lack of balance in the universities being produced.

The Barlow Committee has, however, submitted the early report on broad lines which Mr. Morrison requested, and further recommendations regarding the best use of resources in Britain for scientific development will doubtless be requested later. Meanwhile, it should be recognized that the report does not stand alone. In its emphasis on the factors determining the efficient use of scientific man-power, it reflects current opinion as accurately as the earlier report of the Committee on Scientific Staff in the Civil Service over which also Sir Alan Barlow presided. The importance of research at the universities and the necessity of ensuring that expansion of teaching facilities is not allowed to diminish the opportunity of the university teacher to conduct his own research are maintained as firmly as in the Nuffield College report and other recent reports on industrial and scientific research—for example, in an impressive passage in the Board of Trade Working Party Report on the Cotton Industry which has since appeared. Taking this latest Barlow Report with the White Paper on "The Scientific Civil Service" with its appended report on scientific staff, it must be granted that appreciation of the importance and value of the contribution of science to every side of the national life is fast penetrating the minds of those concerned with the formulation and administration of national policy. Much still remains to be done, but a sound beginning has been made on which a better structure can be built.

# MODERN VIEWS ON EDUCATION

## Total Education

A Plea for Synthesis. By M. L. Jacks. (International Library of Sociology and Social Reconstruction.) Pp. vii + 160. (London : Kegan Paul and Co., Ltd., 1946.) 10*s*. 6*d*. net.

## New Teaching for a New Age

By A. H. T. Glover. Pp. ix + 188 + 20 plates. (Edinburgh and London : Thomas Nelson and Sons, Ltd., 1946.) 15*s*. net.

## Who Shall be Educated ?

The Challenge of Unequal Opportunities. By Prof. W. Lloyd Warner, Prof. Robert J. Havighurst and Martin B. Loeb. (International Library of Sociology and Social Reconstruction.) Pp. xi + 180. (London : Kegan Paul and Co., Ltd., 1946.) 10*s*. 6*d*. net.

USING the starting point that total education caters for the needs of *all* boys and girls and adult members of the community in their infinite variety, the theme of Mr. Jacks' book is that it can only do this if its educational provision is of a like variety. Or, to use a metaphor which he frequently introduces, Mr. Jacks' idea of total education is that of an educational tapestry on which an intelligible pattern can be woven out of a diversity of colours and designs. Among educationists there are probably not many who would not wish to create the general pattern of education for which Mr. Jacks is striving ; dissension would begin and grow when the means to achieve his total education were considered.

Mr. Jacks has built up his case for a working philosophy in education on the assumption that the human mind is more fitted for analysis than for synthesis ; that since synthesis is a more formidable task than analysis, it can be and is only accomplished by select individuals. "It is they who, in the field of science, can attain to a synoptic view of the universe, which comprehends in one grasp not only the individual links in the causal chain, but the chain as a whole, linking together the full experiences of the human mind." So Mr. Jacks develops his theme and argues a skilful, if sometimes wordy, case for the synthesizing activities which would bring together educational administration, the school and the university and what goes on in them, an individual's gainful occupation, his leisure, his home and his life as a citizen of his country and of the world, in order to make the whole man. In this way Mr. Jacks touches upon every influence which he considers could be used as part of the educative process, and in so doing throws out many suggestions and ideas which would be of value to all who are practising education.

For the man of science Mr. Jacks makes some interesting comments, both on the teaching of science itself and on the influence of scientific method through teaching in the school. Science has commonly been treated in schools as one of the most highly specialized subjects, and, as such, loses much of its educational value. If science is to be regarded as a fundamental aspect of modern life, and, therefore, as an essential basis of a modern education for everybody, then science in schools should be considered as a branch of social studies and should link up with all other subjects and interests which fall within that wide category. In this way, writes Mr. Jacks, "it would help to bring about the marriage between the technical and the liberal in a new union of twentieth-century culture, which alone can produce a fully educated generation in all strata of society, instead of a generation split into the technically trained and the artificially cultured". Scientific method, he claims, developed in the laboratory, should be adapted and used in other subjects—if indeed *subjects* are permitted at all—whether in translating Latin unseens or pursuing historical projects.

In advocating the case for total education, however, Mr. Jacks clearly recognizes that it is the teachers who will continue to be the focal point for attack, and he has much sound advice to offer to those charged with the training of teachers. The prospective teacher should be given a philosophy of life upon which he may see his studies in their relation to one another and in their relation to other human activities. In his training-course he must be given time and opportunity to think about education and must, in association with others, consider the all-important question of "Why am I proposing to teach this, that or the other subject ?", a far more important question than "How am I to teach it ?"

Enough has been said to show that "Total Education" is a stimulating treatise on education. If it has defect it lies in the general application of the assumption on which the book has been based—that the human mind is more apt for analysis than synthesis. With masses of grown-up people the analytic reaction to any situation is almost non-existent ; their response can invariably be expressed in terms of "1066 and All That" hedonism ; and, since synthesis cannot take place unless there is something to synthesize, total education may have to be made more total to find a way to make synthetic minds more rational.

Mr. Glover's book, "New Teaching for a New Age", is an example of how both analysis and synthesis can be achieved among school-children. It is a record of experiments carried on in a junior art school in a north of England town, and shows how the use of concrete methods in the school neighbourhood led to creative enterprise and enthusiasm which stimulated individual thought and social co-operation. Using charts and pictures, Mr. Glover indicates how group projects of wide range and fine quality were organised under the following titles : a history of English life ; a history chart ; the development of a city and a world of plenty ; and, by example, indicates how similar projects could be conducted in other schools. This may be one escape from chalk and talk education for which teachers have so long been seeking.

"Who Shall be Educated ?" is a long indictment of unequal educational opportunities in the land where, according to the constitution and popular belief, all men are created equal. Considerable evidence has been collected to show that the American educational system is not only itself a reflexion of the classes into which the United States is socially divided, but, in many respects, the means of perpetuating the system. If the United States is to maintain its democratic way of life, a tremendous job of social engineering must be done so that a larger number of people with ability may function competently in all parts of life. Although the book has been written by Americans for internal consumption, much of its information and advice is appropriate to Great Britain and could be read with profit by all who are concerned to develop the means for total education.

T. H. HAWKINS

# ASSOCIATED LEGENDRE FUNCTIONS

**Tables of Legendre Associated Functions**
By Zaki Mursi. (Fouad I University: Faculty of Science, No. 4.) Pp. viii+286. (Cairo: E. and R. Schindler, 1941.)

IT is indeed curious that, after a lapse of nearly forty years, during which the tables of Tallqwist, first published at Helsingfors in 1906, have remained the only example of tabulation of the associated Legendre functions, two new sets of tables should appear almost simultaneously from entirely different sources. The recent appearance of this volume, actually published in Cairo in 1941, coincided almost exactly with that of another, bearing the same title, prepared by the Mathematical Tables Project in New York in 1945. Fortune has, however, decreed that both sets of tables shall prove to be valuable additions to the world of mathematical literature, for not only are they both more comprehensive than Tallqwist's collection, but in different ways, and much information is to be found in each which is not in the other.

The associated Legendre functions, denoted respectively by $P_n^m(x)$ and $Q_n^m(x)$ where $m$ is the order and $n$ the degree, may be defined as suitably normalized solutions of the generalized Legendre equation,

$$(1-x^2)\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} + \left\{n(n+1) - \frac{m^2}{1-x^2}\right\}y = 0,$$

which arises in problems concerned with the determination of potential functions without axial symmetry, in spherical polar co-ordinates. In particular, if $m$ is zero, it is clear that they reduce to the ordinary Legendre functions, of which the former, denoted merely by $P_n(x)$, is a polynomial of degree $n$, which plays a supremely important part in elementary potential theory. From this as a starting point, it is easy to deduce that if $x$ is a real number numerically less than unity,

$$P_n^m(x) \equiv (1-x^2)^{m/2}\frac{d^m}{dx^m}[P_n(x)],$$

with a similar formula for $Q_n^m(x)$.

Clearly, if $m$ and $n$ are positive integers, $P_n^m(x)$ vanishes identically for $m > n$; and for $m = n$ it is a constant multiple of $(1-x^2)^{m/2}$ for any given $m$. We are thus concerned in tabulation of functions of integral degree only with the case $m \leqslant n$.

In this volume only tables of $P_n^m(x)$ appear, and since

$$P_n^m(-x) \equiv (-1)^{n-m}P_n^m(x),$$

the range $0 < x < 1$ is clearly sufficient. $m$ and $n$ each take all (appropriate) integer values from 1 to 10, and the entries for $x$ are at intervals of 0·001. There are thus 55,000 entries in all, and these are spread over 280 pages. For $n \leqslant 6$ and $m \leqslant 5$, each entry is given correct to eight decimal places; but owing to the magnitude of the functions for larger values of $m$ and $n$ the decimal place accuracy is progressively reduced to four.

Two final pages of Everett coefficients are appended, and by means of these and suitably modified second differences supplied with each functional entry it is possible, following the lines of an example worked out in the introductory pages, to interpolate for intervals of 0·000001 to a remarkably high degree of accuracy.

Eight pages of introductory material provide a very lucid account of the definitions and properties of $P_n^m(x)$, together with an explanation of the methods of calculation of the entries and the checking processes employed. A preface, in Egyptian, at the end, completes the volume, which is admirably bound and clearly printed.

J. H. PEARCE

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# NEW SCHOOL CHEMISTRIES

**A New Introduction to Chemistry**
By H. L. Heys. Pp. 410. (London, Bombay and Sydney: George G. Harrap and Co., Ltd., 1945.) 6*s*. 6*d*.

**Chemistry for Junior Forms**
By A. C. Cavell. Pp. viii + 296. (London: Macmillan and Co., Ltd., 1946.) 5*s*.

IN the interval since pre-war text-books were written many advances in science have been made. New materials (for example, plastics and penicillin) have become widely available, new processes have established themselves and there has been marked progress in our knowledge of fundamental principles. Writers of elementary text-books are now faced with the problem of incorporating this new information into their books, which must at the same time have regard to examination requirements at the end of the school certificate and higher school certificate courses. These two books are both very suitable for school use and should prove popular among science masters and their pupils.

Mr. Heys' "New Introduction to Chemistry" covers much ground and does it extremely well. It begins with a concise historical sketch leading up to an account of combustion phenomena and continuing with an experimental treatment of the air, water, etc. Theoretical principles are then conveniently introduced before the more descriptive sections, these ending with nearly thirty pages on organic compounds. The author gives special attention to the part played by chemistry in the home and in everyday life. He has not hesitated to give, in the appropriate connexion, simple accounts of emulsions; the treatment of sewage; new applications of catalysis and uses of metals; atmospheric pollution; the products from coal and petroleum, the manufacture of petrol from coal, and other things that young readers really like to know.

Mr. Cavell's "Chemistry for Junior Forms" is written rather more simply, but has the great merit that it does not give the results of the experiments the pupil is asked to perform himself. In fact, it is intended that the experiments should be carried out before the rest of the chapter is read. This procedure will, therefore, appeal to those interested in the heuristic method of teaching science. In this respect it would seem that the author has left just enough for the pupil to discover for himself and having found the answer he is stimulated to attack the next problem.

Both books are well illustrated and have good indexes. Both include suitable revision questions at the end of each chapter. In Mr. Heys' book there is one set of questions for short or oral answers and another for longer written answers.

J. G. F. DRUCE

## The World of Numbers

By Herbert McKay. Pp. vii + 198. (Cambridge: At the University Press, 1946.) 8*s*. 6*d*. net.

THERE has been no shortage of books purporting to make elementary mathematics 'popular' during the years since the beginning of the War; but good books of this class have been exceedingly rare. McKay's is a good book. It covers familiar ground, but its freshness, boldness and thoroughness are obviously the product of considerable thought and extensive reading on the part of the author. Numerologists, circle squarers, gematria addicts and perhaps Shakespeare are easy mathematical prey for an author, but McKay goes further by giving Bernard Shaw a severe and well-deserved admonition and by showing how "Whitaker's Almanack" and "Kaye and Laby" come to grief.

The numerous arithmetical calculations appear to be reliable, but a number of minor slips occur in other directions. "One horse-power would boil a pint of ice-cold water in 5½ minutes" means well but is badly expressed; defining a calorie as the heat required to raise a cubic centimetre of water 1° C. (p. 118) is a new idea, and the frequent conversion of decimal answers to a calculation into fractions with awkward denominators is a dubious step seeing that the arithmetic could not be followed without reasonable familiarity with decimals. The introduction of poundal (undefined) on page 98 spoils the continuity of an argument proceeding smoothly in gravitational units, and the fact that "Cavendish found the value of G 6·7", without reference to units, is rather disturbing. The author appears to mean $6{\cdot}7 \times 10^{-8}$ dyne-cm.$^2$ per gm.$^2$, but this does not fit well into an explanation which is wholly in British practical units. The book would be improved if poundals were deleted altogether. Two chapters—those dealing with symbols and imaginary quantities—are out of balance with the remainder of the book. It is little hard on the reader when an author introduces differentiation on one page (as a limiting process without having mentioned either calculus or limits before), differentiates the sine function on the next page, introduces Taylor's and Maclaurin's series on the third and covers the exponential theorem, logarithmic series and series for sine and cosine in the two and a half pages that complete the chapter! The right-angle symbol for factorial is, presumably, still regarded as a matter of opinion. Its bursts into renewed life in Great Britain are less and less frequent—it will soon be dead. These are minor criticisms of a readable and well-written book.

## Birds in Colour

By Walter E. Higham. Pp. 176 + 48 plates. (London: Wm. Collins, Sons and Co., Ltd., 1946.) 25*s*.

MR. HIGHAM'S book is an addition to ornithological literature of which he and his publishers might rightly be proud. As the title indicates, the main purpose of the book is to present some of the remarkable coloured photographs which the author has so assiduously and skilfully collected. Altogether there are eighty-nine photographs, and many of them are cuttings from the three coloured films, "British Featherland", "Featherland of the Farne Islands and the Bass Rock" and "Hungarian Featherland", which were the products of Higham's resourceful camera. The photographs, from his Hungarian film, of birds which, like the purple and great white herons, are uncommon visitors to Britain, bring added charm and value for readers whose connexions with mid-European avifauna have been so long interrupted. The text is incidental to the photographs, and, although it contains little new for the specialist, would be of particular interest to the beginner as an introduction to the science and art of bird-photography.

In recommending this work to all bird-lovers, it must be said that the photographs themselves are mixed in quality, and that much remains to be done technically before the bird photographer can fairly claim that his coloured pictures are accurate reproductions of all the shades and tones of his models. Too many of Higham's birds, for example, have eyes which are but blacked-in circles containing white spots excentrically placed. The author can feel gratified, however, by the awareness that his efforts in colour photography will have done much to extend an ever-growing circle of bird-watchers and to improve the science of colour photography. T. H. H.

## Colloids

Their Properties and Applications. By A. G. Ward. Pp. vi + 134 + 6 plates. (London, Glasgow and Bombay: Blackie & Son, Ltd., 1945.) 5*s*. net.

THE scientific study of colloids has made great strides between the two World Wars. This is clearly brought out by comparing Mr. Ward's book with Hatschek's "Introduction to the Physics and Chemistry of Colloids" which was published in 1919 (third edition). The new knowledge of colloids has arisen mainly from studies of the behaviour of monomolecular and polymolecular films at surfaces and interfaces, and from studies of natural and synthetic polymers, studies which have enabled the classical physical laws to be extended to the special case of colloids. Mr. Ward's book deals clearly and concisely with these advances in our knowledge. It is divided into three parts: the nature of the colloidal state, colloidal systems, and colloids in industry and in living matter respectively, thus enabling the reader to find what particularly interests him without much effort. There is a short but carefully selected list of books for further study.

The author's modest claim to have written an elementary account of colloid science is fully substantiated. It is in fact a stimulating little book which can be read with profit, both by those with little previous knowledge of the subject and by those who wish to renew an old acquaintance with a fascinating and rapidly expanding field. E. H. CALLOW

## An Introduction to Industrial Mycology

By George Smith. Third edition. Pp. xv+271. (London: Edward Arnold and Co., Ltd., 1946.) 20*s*. net.

THE earlier editions of this very useful book were remarkable for the clarity and quality of the photomicrographs. They are still better in the third edition, and seven more have been added, while four "which were not considered satisfactory" have been replaced. This results in an even more useful volume. It serves alike as a readable introduction to mycological technique and literature, and a work of reference for the specific uses of mould fungi in industry. Time has but strengthened the high praise of an earlier review (*Nature*, **152**, 173; 1943). The text has only been changed in detail, as war-time restrictions were still in force when it was revised. It must be left to subsequent editions to describe many of the interesting problems involving the activities of moulds which have arisen in various industries during the war years. J. G.

# PROGRESS IN AERONAUTICS*

By Sir BEN LOCKSPEISER
Ministry of Aircraft Production

IT is just over forty years since the Wright Brothers flew at Dayton and fulfilled a dream that man had cherished throughout the ages. During the last three months of 1945, in large-scale trooping operations following the end of the Second World War, R.A.F. Transport Command flew 20,000 men back to England from the Far East; while American Transport Command in the summer of 1945 flew 5,000–6,000 men a month across the Atlantic. These few sentences give the measure of aeronautical progress, impressive by any standard.

## Evolution of Structural Design of Aircraft

Many minds, many sciences, many industries have made this achievement possible. The typical aeroplane has evolved during the last thirty years from a wooden skeleton covered in fabric. Increase in speeds made the drag of external struts and bracing prohibitive and the distortion of fabric under aerodynamic pressure unacceptable. Heavier wing loadings turned designers towards light alloys. The constant urge to keep down drag led to retractable undercarriages, reduction of body-size and elimination of equipment carried in the airstream. Space became as serious a preoccupation as weight and the wing space was utilized to the full for stowing wheels, housing fuel tanks and for the carriage of any part of the load which the skill of the designer could place there. So we have arrived at the modern streamline monoplane built up of hollow shells in duralumin, of which the Tudor, a civil transport type, is a typical example.

In steady horizontal flight the lift on the wings is roughly equal to the weight of the aircraft, the tailplane carrying a small load to maintain equilibrium in pitch, but either deliberately by the execution of manœuvre by the pilot or fortuitously by atmospheric gusts, the wings may be loaded to several times the aircraft weight. By violent use a pilot can break up any aeroplane in the air, and it is necessary for designers to know what loads are actually or likely to be encountered in flight. In comparable land-based problems additional structural strength can usually be obtained by increased weight without any great difficulty. But the aircraft designer is brought up in a very hard school. He knows that every pound weight put into the structure robs the payload of a pound, and he very properly asks for exact knowledge on which to base his design.

For this purpose it is necessary to know both the acceleration normal to the flight path and the forward speed at the same instant. From these the aerodynamics and load distribution can be deduced. This information is provided by an instrument called a *V-g* recorder which gives a continuous plot of acceleration against air speed. These recorders, which are left in the aeroplane for long periods, were fitted to a large number of Service aircraft during the War, and records were obtained over hundreds of hours of flying. Statistical analysis of these records has enabled load-factor scales to be established according to the aircraft size, duty and speed.

The importance of exact information of this nature in relation to atmospheric gusts can be appreciated from the fact that in the case of the new civil airliner, Brabazon I, increased structure weight to withstand gusts of a vertical velocity of 50 ft./sec. would have entailed a pay-load penalty of 3·5 tons.

## Reduction of Drag

The parasitic drag of aircraft having been largely eliminated by the revolution in structural design, a constant urge to reduce drag has caused much attention to be devoted in recent years to a detailed study of a fundamental character, of the nature of air flow around aerofoils, or wings, with important consequences to the further reduction of drag.

These investigations show that when air flows over an aircraft wing surface at speeds at which air behaves substantially as though it were an incompressible fluid, it may do so in one of two ways. In one type of flow the wing as it speeds through the air drags a thin layer of air with it as though this layer were composed of a pack of very thin cards. The lowest card moves with the wing and each card drags and slips past its neighbour, the top card of the layer remaining at rest. This particular type of flow is called laminar flow. The actual layer affected, the so-called 'boundary layer', is itself comparatively thin, and the air above is quite unaffected.

In the other type of flow, called turbulent flow, the air is set in rotational or eddying motion. This mixes up the air and causes a considerable increase in drag. Turbulence, in fact, is a means of wasting energy.

But the most serious cause of loss of energy arises when the air separates from the surface. This separation may occur in laminar or turbulent flow. Instead of the streamlines running in a direction parallel to the wing, they depart from it at an angle and cause a large-scale irregular turbulence which builds up to a wide wake and causes a large increase in drag.

The drag of a wing with laminar flow around it is generally many times smaller than one in which separation occurs, particularly when the separation point is well forward. If it were possible to produce laminar flow over the whole surface the least possible drag would be obtained and the least possible price paid in getting the wing through the air. It would then slip through the air in the same way as a piece of wet soap slips through the fingers.

## Laminar Flow Wings

We know how to obtain laminar flow over a large part of wing surfaces and we have achieved it both in the wind tunnel and in flight. The conditions required are threefold. First, the air through which the aircraft flies must itself be free from turbulence; secondly, the pressure conditions along the wing must be favourable, that is, the pressure must fall steadily; and thirdly, the surface of the wing or body must be very smooth and free from waviness. The third condition is very exacting, as the surface smoothness must be equivalent to that of writing paper, and any waviness of the surface must be restricted to one or two thousandths of an inch in 2 inches, measured in the direction from leading to trailing edge of the wing. Rather more waviness can be tolerated in the direction along the span.

Fortunately, the first condition is always satisfied in free air, which is much better in this respect than the best wind tunnel. We know how to satisfy the second condition over a large part of the surface by providing wing sections of special shape. This is a problem which has been solved by mathematical methods, and a group of very able mathematicians

* Friday evening discourse at the Royal Institution delivered on March 29.

in Britain has made outstanding contributions to this work. The third condition is a question of manufacture and maintenance. Difficult problems are involved, but our designers and manufacturers have already gone a long way towards solving them.

The difficulty of maintaining so true a wing surface in flight is increased by the liability of the wing to pick up, at low altitude, dust particles and insects which are frequently sufficiently large to cause local breakdown of the laminar flow to the turbulent form. This problem has been studied in flight at the Royal Aircraft Establishment by an ingenious method which results in dark patches upon the wing surface where the air flow is turbulent but not where it is laminar.

Fortunately, the upper atmosphere is normally free from both turbulence and foreign bodies, and the practical problem for the future consists in protecting the wing surface during take-off and climb to operating altitude. The sacrifice of the advantages of laminar flow during this period is of little consequence, and a solution of this problem is now being actively sought.

## Wing Suction

It has not been possible to obtain laminar flow, even experimentally, over the whole of the wing surface, although we have been successful over the larger part. It is not possible to maintain a falling pressure gradient over the whole of the wing profile; at some point towards the rear, the laminar type of flow changes to the turbulent variety, which may break away from the surface of the wing and give rise to a turbulent wake. We are not likely to succeed by cunning aerodynamic shapes and skilful manufacture alone. It may be necessary to supplement these by providing suction slots on the wing surface to divert a part or whole of the air boundary layer into the wing to provide a more desirable type of air flow. Wing suction will probably play an important part in the evolution of the wing design of the future. Flight with heavier-than-air craft is only possible because of the existence of aerofoils (that is, shaped bodies) the lift of which is many times greater than their drag; and in the ceaseless quest to maximize lift and minimize drag, control of the boundary layer by suction or even by blowing will probably play a significant part. The aircraft wing of the future, relying perhaps as much on the partial removal or the reinforcement of the air boundary layer as on the shape itself for controlling the air flow, will no doubt be a more complex affair than present-day wings. A price will, of course, have to be paid for this complication, but as it is hoped eventually to obtain a wing drag of not more than about one-third of what is now common, the price should be well worth paying.

## Tailless and All-Wing Aircraft

It is not at all easy, indeed it may be impossible, to treat the body or fuselage in the same way, and this leads directly to the conclusion that for very low drag, aircraft for speeds not comparable with the speed of sound should be built either with bodies of greatly reduced size or better still without bodies and tail-planes. We thus arrive inevitably at the conception of the tailless aircraft, of which the glider constructed by Armstrong Whitworth is a typical example. The function of the tail of a conventional aircraft in providing the necessary elements of stability and control is fulfilled in the tailless aircraft by sharply sweeping back the wings and fitting what are called 'elevons' to the rear outer part of the wings. These are used differentially as ailerons to control the aircraft in roll or in unison as elevators to control it in pitch.

Pressing this line of thought to its limit, it should be possible to do away with the body altogether and arrive at the conception of an all-wing aircraft large enough to house the pilot, crew and passengers in the wing. Apart from the low-drag possibilities of such an aircraft driven by jet propulsion, it is likely to show a considerable saving in structure-weight over the conventional type in the very large sizes, say those more than 100 tons. This, of course, is only the technical side of the story. The degree of comfort which it is possible to provide in an all-wing aircraft may not be acceptable, but I believe that this disability, if it exists at all, will not operate for night flying. Sleeping berths in a wing can be made every bit as comfortable as those in a conventional aircraft body, and I think it very likely that fast long-distance all-wing civil aircraft will emerge as the best type of aircraft for night passengers and mails. Long-range flight on the main trunk routes of the world demands the highest practical cruising speeds, the aim being to connect the principal capitals of the world by overnight service. This means high speeds both to take account of headwinds, which may be up to 100 miles an hour on the North Atlantic, and to compensate for loss of clock-time when travelling in an eastward direction.

## Consequences of Flying at the Speed of Sound

Implicit in the theory underlying the achievement of low drag is the conception of air as an incompressible fluid, and for bodies moving at speeds below and not comparable with the speed of sound this conception is substantially true in practice. The velocity of sound in air at sea-level is about 760 m.p.h., and the effect of the compressibility begins to make itself sensibly felt above about 500 m.p.h. The effect of compressibility is to produce an increased drag rapidly increasing with rising speed and reaching, at the speed of sound, a value many times greater than would be encountered under conditions of incompressible flow.

It is not immediately obvious why the speed of sound should play such a dominating and decisive part, and perhaps a few words from a purely physical aspect will not be out of place.

The air flow past an aerofoil at a speed well below the speed of sound or, as it is called, a low subsonic speed, conforms to a smooth flow pattern which extends forward of the aerofoil. The air ahead of the aerofoil is prepared in advance for its arrival, part being accelerated to flow over the upper surface and part over the lower surface. Clearly, the moving aerofoil possesses as it were a signalling system to warn the air ahead of its approach and allow it to take full advantage of its shape to slip through. To comprehend this phenomenon it must be remembered that with such a flow pattern are associated the pressure changes in the air which are the source of both lift and drag of the aerofoil. Pressure changes in any medium are not transmitted instantaneously, but with a finite velocity, and this velocity for pressure changes of the order of magnitude under consideration is approximately the speed of sound in air.

It follows, therefore, that if the aerofoil is travelling at or above the speed of sound (or sonic and supersonic velocity) it is robbed of any means of 'signalling' ahead. The air can no longer be prepared for its

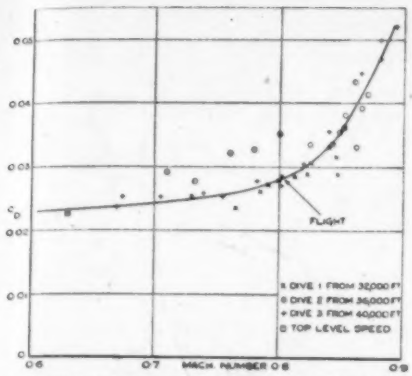


Fig. 1. DRAG MEASUREMENTS IN FLIGHT AT HIGH SPEED. CROWN COPYRIGHT RESERVED

arrival. The aerofoil can no longer slip through the air, which it now meets, inevitably head on, producing a shock wave which is the source of the largely increased drag. During the passage through a shock wave a certain amount of the mechanical energy content of the air is converted irreversibly, in a thermodynamic sense, to heat energy. This irrecoverable transformation of heat energy represents the work required to overcome the drag associated with the shock wave. If further there is separation behind the shock wave, thus producing a shock stall, the resultant eddying motion dissipates further energy.

The speed of sound in air varies as the square root of the absolute temperature and therefore decreases with altitude. It falls continuously from 760 m.p.h. at sea-level until the stratosphere is reached, where the speed is 660 m.p.h. In the stratosphere, which extends from above 36,000 ft., the temperature, and therefore the speed of sound, is constant at about this figure. A given aircraft speed represents a higher fraction of the speed of sound at altitude than at sea-level; and since this fraction is a significant factor in compressibility phenomena, it is convenient to speak of the Mach number, that is, the ratio of the forward velocity to the local velocity of sound, in dealing with the performance of high-speed aircraft.

Fig. 1 shows how the drag coefficient of the Spitfire varies with Mach number. The values at high Mach number have been obtained at the Royal Aircraft Establishment by steep diving at high altitudes. The highest Mach number recorded in these experiments was 0·92, corresponding to a true aircraft speed of 620 m.p.h. at 31,000 ft. I should like here to pay a tribute to the experimental skill of those engaged in this work and to the superb flying qualities and courage of the pilots who cheerfully undertake this risky experimental flying. We have always been extremely fortunate in the happy working partnership of scientific workers and Service pilots, whose willing co-operation makes progress in aeronautical science possible.

Because of the acceleration of the air over certain parts of the structure, the aircraft velocity relative to air in these regions may reach the local velocity of sound, although the forward speed of the aircraft is below it. The Meteor, which recently won the world speed record, provided an interesting case of the same kind, where it was found from wind-tunnel tests that shock waves formed with subsequent breakaway of flow in the region of the maximum thickness of the engine nacelles. The consequent increase of drag and very severe buffeting would have limited the top speed to 565 m.p.h. The problem consisted in reducing the acceleration of the air by diminishing the curvature of the surface, that is, by slimming the nacelle. The dimensions of the Derwent engine allowed no reduction of the diameter, and the only solution lay in lengthening the nacelle both fore and aft. This delayed the excessive drag rise and allowed a forward speed of more than 600 m.p.h. at sea-level. But for the largely increased drag due to the compressibility, the Meteor with the thrust of the Derwent engine would have reached a sea-level speed in level flight of 720 m.p.h.

Aeronautical science is largely occupied at the present time in overcoming the difficulties associated with the compressibility of air at high speeds. Three methods appear to be open for delaying the upward speed of the drag coefficient curve with Mach number. The first, as has already been indicated, lies in reducing curvature wherever possible, which leads to thin wings and slim nacelles and bodies.

The second lies in large sweep back of the wings. This important and significant advance in aerodynamic theory and practice for high-speed flight was made in Germany during the War. In its simplest form the theory indicates that for wings of infinite span an advantage in critical Mach number from $M$ to $M\sec\theta$ should be gained by a sweep back angle of $\theta$ from the square wing position. In fact, wind-tunnel experiments on high-speed swept-back wings show a possible gain of about half the theoretical amount. But this, of course, is very considerable. Thus a sweep back of 40° should, in aircraft of high subsonic speeds, allow an increase in forward speed of the order of 90 m.p.h. over that attainable with the square wing.

The third line of advance lies in small aspect ratio. The need for high aspect ratio wings is dictated in the subsonic region by the necessity to minimize induced drag. But at near sonic and supersonic speeds wings become almost free from induced drag, and structural engineers will no doubt rejoice in being free to design stubby wings for very high-speed aircraft.

These three lines of reasoning lead logically to a design of a high-speed aircraft resembling an arrowhead. In fact, a wind-tunnel model of an aircraft designed by Lippisch on these lines was recently found in Germany.

At supersonic speeds, shock waves govern everything. Any flying object has a well-developed shock wave at or near its forward end, and in the case of sharp-edged wings, a theory can be devised which allows forces and moments to be estimated, in very much the same way as for blunt-nosed wings at low subsonic speeds. Limitations on the use of wind tunnels for tests of wings disappear at about $M = 1{\cdot}25$, and quite reasonable agreement between theory and experiment is found above this point. It is worth noting here that theory at supersonic speeds has not, so far, taken account of the viscosity of the air; but the frictional forces thereby neglected do not seem to be of importance compared with the effects of the pressure changes which occur with shock waves. Drag coefficients, for $M$ greater than about 1·25, decrease, though, of course, absolute values of drag continue to rise.

Flight at supersonic speeds introduces new problems in control. Supersonic aircraft must, at some period in their flight, pass from subsonic to supersonic conditions, and this produces a change from a more or less constant trim condition to another which is

different but also more or less constant. The aerodynamic centre of a wing moves 25 per cent of the wing chord farther back, and in addition the tailplane suffers much loss from the effects of the wing in front of it. The aircraft tends to become very much more stable. This means, unfortunately, that it is also much less manœuvrable; too much stability, for a craft required to be manœuvred rapidly in flight, is undesirable equally with too little.

A supersonic aircraft must therefore be designed to cope with both subsonic and supersonic aerodynamic regimes, and because of peak drag coefficient values which occur near Mach number 1 the transition between the two regimes will have to be accomplished as quickly as possible. There will also be a number of difficult ancillary problems to solve. The over-riding need for slimness in design will probably dictate the prone position for the pilot, desirable also on physiological grounds for withstanding high accelerations normal to the flight path, and we shall have to learn how to get the pilot clear in an emergency. Much intensive research will be necessary before human flight at supersonic speeds becomes possible. Supersonic aircraft are certainly not just round the corner.

## Power Plants

*Gas turbine.* It is fortunate that at this moment in the evolution of aerodynamics, entirely new power plants capable of higher thrusts per unit cross-sectional area than the piston engine—a vital consideration in high-speed flying—should have been brought into being. Of these, the gas turbine with either propeller or jet propulsion (the latter is often called the 'turbo jet') is of the greatest present significance.

The two forms of propulsion by jet and propeller are characteristically different, but they are not different in principle. The propeller collects air, accelerates it by the action of its blades and discharges it to the rear. The turbo jet collects air through its intakes and, after burning it under pressure with fuel, discharges the resultant gases to the rear at high speed through a jet pipe. The propeller deals with much larger mass air flows but at lower discharge velocities than the turbo jet, and the efficiencies of the two means of propulsion vary according to forward speed (Fig. 2). At low aircraft speeds, the propeller is much the more efficient; but the efficiency of the jet increases rapidly with speed while that of the propeller falls. The jet begins to overhaul its rival at 600 m.p.h. and at 700 m.p.h. is well ahead. This coupled with the low frontal area of the gas turbine unit are the main reasons why the turbo jet is so eminently suitable for propulsion at high speeds.

At low speeds the turbo jet is much less economical in fuel consumption than the piston engine; but taking into account the lower specific weight of the gas turbine, the balance can be more than redressed by coupling the turbine engine to a propeller. It must be remembered that the gas turbine is in its infancy. Its future lies in higher compression ratios and higher working blade-temperatures. Intensive study is now being made of the design of aerofoils suitable for use in compressors operating at high speeds. These studies are in the first place made in wind tunnels particularly designed to give us knowledge of the flow through a row of blades. They are called 'cascade tunnels' from the arrangement of blades in a cascade. The next step in the work is to study the flow in a single-stage compressor, and the final experiments are done on a multi-stage compressor.

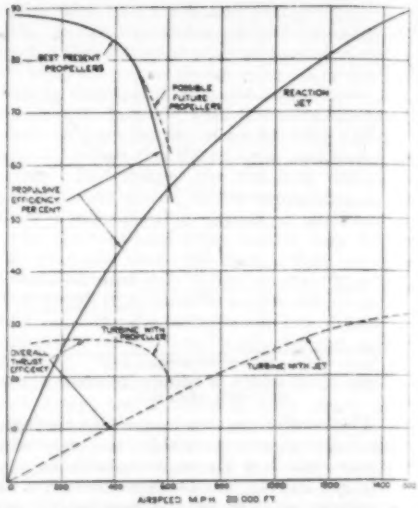


Fig. 2. COMPARATIVE PROPULSIVE AND OVERALL THRUST EFFICIENCIES. CROWN COPYRIGHT RESERVED

This work will undoubtedly result in the near future in axial flow compressors having high efficiency and double the present compression ratio.

The efforts of metallurgists should enable working blade-temperatures to be raised well above the present level of about 700° C. to about 900° C. in the course of the next few years. Blade cooling may enable gas working temperatures to be raised higher still. The Germans worked on this because of their shortage of suitable materials, and at one German research institute a gas turbine with water-cooled blades has been run with a temperature of 1,200° C.

*Propulsive duct.* At supersonic speeds the total head pressure at the entry duct becomes so high that a compressor becomes superfluous. At 1,250 m.p.h. at sea-level (Mach number 1·65), for example, the total head pressure is about 59 lb. per sq. in., corresponding to the compression ratio of about 4 : 1 of existing turbo jets. Since a turbine is only necessary to drive the compressor, the turbine becomes superfluous also. This leads directly to the simple conception of a shaped tube, called a propulsive duct, without any moving parts, as a power unit for supersonic flight. Air is encountered at supersonic velocity and is reduced to subsonic velocity through a shock-wave entry before reaching the combustion chamber. The shock loss at entry varies with Mach number. The duct is designed to allow a speed of about a tenth that of the aircraft velocity through the combustion chamber, where fuel is burned under conditions of constant pressure. The burnt gases are then ejected through the jet pipe. The thermodynamic cycle is thus precisely similar to that of the turbo jet. At low speeds the propulsive duct is, of course, very inefficient, and some form of boost is required to accelerate the speed to a sufficiently high value at which the propulsive duct can operate economically.

*Liquid rocket motor.* The third type of power unit likely to prove of great value in aircraft propulsion is the liquid rocket motor, the characteristic feature of which is that, unlike the power units already described, the oxygen for combustion is not drawn from the surrounding atmosphere but is self-contained within the fuel. The main advantages of the rocket

motor are : (i) its comparative simplicity and cheapness ; (ii) the high thrust per unit area of combustion chamber cross-section that can be obtained—10,000 to 30,000 lb. per sq. ft. are common ; and (iii) the maintenance of approximately constant thrust with altitude ; this is peculiar to the rocket motor and is of particular significance in obtaining high rates of climb at high altitudes.

But, of course, a heavy price has to be paid for these characteristics. The rocket motor burns fuel extravagantly to provide the maximum possible thrust. Its specific fuel consumption is very high, about 15–20 lb. of fuel being consumed per hour per pound of thrust, as compared with a corresponding figure of 1–3 lb. for the various air-consuming systems. This type of propulsion is best suited for special purposes, for example, for assisted take-off for aircraft, for increasing the performance of interceptor aircraft during the climb and during combat, or for boosting aircraft from the subsonic to the supersonic range.

The rocket motor has been developed to a remarkable degree of excellence by Dr. Walter of Kiel in Germany, one of whose motors formed the power unit of the interceptor fighter Me. 163, which represents the only example to date of an aircraft powered solely by a rocket motor. The design is interesting as embodying the large sweep back, shortened body and absence of conventional tail unit, advantages for high-speed flight which have already been mentioned.

The specific impulse of the rocket motor, defined as thrust in lb. produced per unit rate of burning (1 lb. per sec.), is proportional to (*a*) the square root of the ratio of the absolute temperature of the gases before expansion to the molecular weight of the jet mixture, and (*b*) to a term involving the ratio of specific heats and expansion ratio. Term (*b*) is relatively constant for all fuel and design systems. The temperature/molecular weight ratio is thus the important variable, and the highest possible combustion temperature and the lowest molecular weight are required. The temperature is seriously limited by the material of the chamber walls : combustion temperatures of 2,000–3,000° C. are encountered at present, and metallurgical and chemical calculations make it unlikely that in the foreseeable future these temperatures can be raised appreciably. The main hope of improving the specific impulse therefore lies in the lowering of the molecular weight.

The molecular weights of present-day jet gases are in the neighbourhood of 20, and apart from hydrogen and helium there are no other gases, suitable at high temperatures, which have significantly lower molecular weights. A liquid oxygen – liquid hydrogen system could give a specific impulse about 50 per cent higher than that of the best fuels now used. But apart from difficulties of handling, the most serious drawback of this system is the low density of liquid hydrogen, which leads to a considerable increase in 'dead' weight for the same weight of fuel. Fuel density is an important secondary consideration of efficiency. Indeed it is found that in most applications this fact more than offsets the higher specific impulse, and it is generally agreed that fuel systems with significantly greater specific impulses than those in use are not likely to come into practical operation in the foreseeable future.

*Comparisons of new types of propulsion.* The efficiencies of these new types of propulsion, expressed in terms of thrust h.p. per weight of fuel consumed per hour and forward speed at 36,000 ft. and above, are shown in Fig. 3. With the exception of the rocket

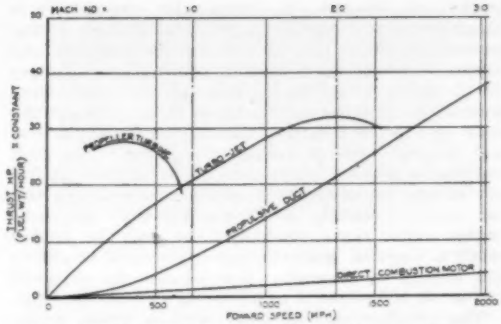


Fig. 3. Power plant efficiency comparison for an altitude of 36,000 ft. and above. Crown copyright reserved

motor, each type of power plant possesses a dominating advantage over a particular speed-range. Thus the propeller turbine holds the field up to about 600 m.p.h. The turbo jet takes over from this speed to about 1,600 m.p.h., when the superior efficiency of the propulsive duct asserts itself. The rocket motor makes a poor showing on this diagram, but, as has already been explained, its usefulness is based on other grounds than efficiency.

## Helicopters

So far we have only considered aircraft which derive their lift from stationary wings, but the first attack on the problems of flight, long before this was mechanically possible, was in imitation of the bird. Flapping and rotating wings were the object of detailed study so far back as the fourteenth century, and Leonardo da Vinci left several valuable and interesting sketches of an aircraft-like machine with lifting screws rotating about a vertical axis, now called a helicopter.

An aircraft of this type which will rise vertically from the ground, hover, descend vertically, either at will or in the event of engine failure, and fly horizontally at a reasonable speed possesses obvious attractions. It also presents many obvious aerodynamic and mechanical difficulties. Several types of aircraft designed to solve these problems have been worked at, on and off, during the last twenty years, but it was not until Sikorsky built his helicopter in America during the War that a widespread interest in helicopters was aroused. Three German experimental types, the Focke, Flettner and Doblhoff, have also flown successfully.

To maintain safety the rotor blades must, in the event of engine failure, autorotate without stalling. This condition becomes increasingly difficult to sustain as the forward speed increases. The forward thrust in the helicopter is obtained by tilting the rotor disk forward with respect to the flight path, and an increase of forward speed entails an increase in axial flow through the rotor. This results in a reduced blade angle of attack, which in turn demands an increase in blade angle, generally greater at high forward speeds than the maximum value at which the rotor would autorotate in unpowered flight. Engine failure therefore calls for a very rapid alteration of the pitch of the blades. Automatic means for doing this will no doubt be introduced in the future, and any such mechanism must take account of the fact that changes in axial flow through the rotor do not alter the blade angle of attack equally along the span, the tip being least affected.

With the present designs of helicopters, a

height of 50–100 ft. from the ground is a dangerous one in the event of engine failure during hovering flight. This is because stoppage of the power, followed by autorotation of the blades, changes the direction of airflow through the rotor disk from downwards to upwards. It takes time to change the state of flow, and during the process height is lost and a large vertical velocity is gained. For disk loadings of present helicopters, of the order of 2¼ lb./sq. ft., the loss of height would be about 100 ft. and the vertical velocity 30 ft. per second. The helicopter under these conditions can only be landed safely if a special undercarriage is provided to absorb the energy of descent; this cannot be achieved except at the expense of increased structure weight.

The problem can be dealt with in three ways: (i) by reducing the disk loading; (ii) by increasing the mass of the rotor, so increasing the amount of stored energy; (iii) by putting excess power into the rotor, another means of increasing the stored energy. All these solutions present difficulties, but it is very likely that one of them or a combination will be used in future designs.

In all helicopters in which the blades are driven by externally applied power, the rotor torque must be balanced out. In the Sikorsky helicopter a small auxiliary rotor driven from the engine and located at the tail gives thrust at right-angles to the line of flight. An alternative solution to this problem lies in using a pair of rotors rotating side by side in opposite senses, as in the Focke helicopter.

In the Flettner helicopter, intended for shipborne operation, there are two intermeshing bladed rotors, the two drive shafts having an included angle of 24°, and the centres of the two hubs being about 2 ft. apart. Longitudinal and lateral control is obtained by joint cyclic pitch change of the two rotors. Yawing control is by a combination of rudder and differential pitch control of the two rotors. A blade pitch governor is provided which holds the rotor revolutions per minute (r.p.m.) constant within certain limits, the lower limit being the safe r.p.m. in the case of engine failure.

The Doblhoff type is an experimental single-seater helicopter, in which a single rotor is driven by jets on the blade tips. There is, of course, no torque to be balanced out in this case. An aircraft engine is used to drive a supercharger, and the compressed air is mixed with fuel which is metered to maintain the correct fuel/air ratio. The combustible mixture is ducted to the hub and out through the three blades where it is burnt in combustion chambers at the blade tips. The fuel consumption is, of course, very high, and it was the intention of the inventor only to use the jets for relatively short periods for hovering, take-off and landing, translational flight being obtained by reverting to the auto-rotational regime, for which purpose a pusher propeller could be clutched to the engine.

The possibilities in an aircraft which is not tied to specially prepared aerodromes and can land and take off from any clear space slightly bigger than its own dimensions are obviously far-reaching. The helicopter will probably become the air taxi of the future, transporting passengers from the main airports, situated outside towns because of their very large size, to town centres. Large stores, clubs and office blocks will doubtless provide themselves with flat roofs for the landing of helicopters, and it may be expected that the helicopter will eventually be used on a large scale for private flying.

# THE MULTIPLICITY OF FORAMINA MENTALIA IN A HUMAN MANDIBLE FROM THE COPPER AGE OF ANATOLIA

By Prof. MUZAFFER SÜLEYMAN ŞENYÜREK
University of Ankara

During the course of an investigation on ancient Anatolian crania, I found a mandible with four or five foramina instead of a single foramen mentale. I am reporting it here as it is a very rare case, if not indeed the first one, reported for *Homo sapiens*. In fact, Prof. F. Weidenreich[1] in his exhaustive monograph on the mandibles of *Sinanthropus pekinensis* (p. 29) quotes Simonton to the effect that "four or five foramina have never been found in recent man regardless of race". The same author also cites Akabori as never having observed four or five foramina among the Japanese.

The mandible under discussion (Kusura No. V.94.76) is from the copper period of Kusura, a site near Afyonkarahisar excavated by Miss Winifred Lamb, and is preserved in the Department of Anthropology of the University of Ankara. On the right side of the corpus mandibulæ (Fig. 1, *b*)* there are five foramina located in a well-defined depressed area of oval shape. The line connecting the lower boundaries of the foramina forms a curve, with convexity toward the

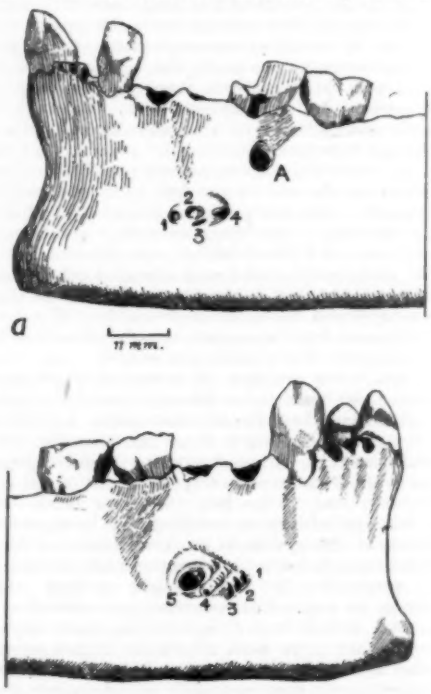


Fig. 1. Mandible from Kusura (No. V.94.76), near Afyonkarahisar, Turkey. *a*, left side; *b*, right side of mandible. The foramina are shown by numbers 1–5. The large hole, A, in upper figure is not a foramen, but is due to a badly abscessed first molar

* I am grateful to my colleague, Prof. W. J. McCallien, for the illustrations accompanying this article.

base. This curve represents the lower and the anterior sides of the above-mentioned oval area. The three anterior apertures are closely placed and are all directed forward and downward. A little way behind these, and at the bottom of a small depression, is found a smaller foramen (the fourth) with a backward and downward direction. Behind this is the largest foramen of the cluster, with a maximum diameter of 3·4 mm. This foramen is directed backward. The maximum distance between the foremost and the hindermost foramen is 10 mm.

On the left side (Fig. 1, *a*) there are four foramina, but the oval depressed area is not clear on this side. The line connecting the lower foramina again forms a curve with convexity toward the base. The foremost aperture is directed forward. Behind this is a larger foramen with a general forward direction. However, it is found that this is a composite foramen, or a deep depression containing at its bottom four small orifices, three of which are directed forward and one backward. A little way behind and below this is found the third foramen, which is a rather slit-like opening directed forward and downward. Behind this is the fourth or largest foramen with a maximum diameter of 3·3 mm., directed backward and downward. The maximum distance between the first and the last foramen is 11 mm.

The vertical position of the foramina was ascertained by means of an index, which has been adapted from Schulz[2]. This index expresses the distance of the middle point of the cluster of foramina from the lower margin of the mandible as a percentage of the corpus height. I have measured the corpus height both to the middle of the alveolus of *P*2 and to the highest point of the interalveolar septum of *P*1 and *P*2. The indices obtained with both corpus measurements are as follows:

| | Right | Left |
|---|---|---|
| Corpus height to the middle of the alveolus | 48·0 | 46·5 |
| Corpus height to the highest point of the interalveolar septum .. .. .. | 45·0 | 44·0 |

The figures show that the foramina are somewhat nearer to the base of the mandible than to the alveolar margin, and that the foramina on the right side are at a slightly higher level than those on the left. Though this relatively low position may be looked upon as being suggestive of a rather primitive feature, it is nevertheless still within the normal range of variation of recent man and cannot be considered to be distinct from theirs, as very low positions are found among modern Württembergers and ancient Egyptians (ref. 2, Table 20).

As for the position of the foramina relative to the teeth, on the right side the foramina are between the level of the distal part of the alveolus of *P*1 and the level of the interalveolar septum of *P*2 and *M*1, the middle point of the cluster corresponding to the mesial part of the alveolus of *P*2. The foramina of the left side are slightly more distal than those of the right side and they range between the level of the interalveolar septum of *P*1 and *P*2 and the mesial root of *M*1, the middle point of the cluster being underneath the mid-point of the alveolus of *P*2.

R. Martin[3] states that in recent man the foramen mentale is in most cases underneath *P*2, as is also shown by Table 21 of Schulz[2]. Thus the position of the foramina in our mandible does not differ much from that of other forms of recent man and the difference chiefly involves the number of the apertures.

Regarding the multiplicity of the foramina, Prof. Weidenreich[1] quotes Simonton to the effect that more

Fig. 2. Right side of mandible from Kusura (No. V.94.76)

than one aperture occurs in 14·4 per cent of *Gorilla*, 39 per cent of Pongo and 15·6 per cent of Pan. Also, he states that in *Sinanthropus pekinensis* the number varies between two and five. The average of six *Sinanthropus* mandibles is three. For Neanderthal man, the late Dr. Hrdlička (ref. 4, p. 321) states that the foramen mentale is "often multiple, not seldom duplicate or triple". Of the eight skulls of Neanderthal man cited by Prof. Weidenreich[1] six have two foramina, one three, and one (Heidelberg man) three on one side and two on the other. According to Dr. T. D. McCown and Sir Arthur Keith[5], the number is two for the Gibraltar child and Tabun individuals and only one for the Skhūl type. It appears that the number of foramina mentalia in Neanderthal man is less than in *Sinanthropus* and it is usually not more than three. However, more than three foramina may also occur in this species as a rarer variation, as according to the statement of the late Dr. Hrdlička (ref. 4, p. 293) in the second mandible from La Quina there are five orifices, three large and two small. According to the data cited here, the average number of foramina for *Homo neanderthalensis* is about two.

In *Homo sapiens* the foramen mentale is generally single. According to Prof. Weidenreich[1], Simonton has found three foramina in 0·19 per cent and two apertures in 4·3 per cent of recent man, while Akabori has observed three foramina in 0·73 per cent and more than one in 3·7 per cent of the Japanese. It would appear that among recent man there is relatively small amount of variation in this respect. But, as is shown by the mandible discussed here, the limits of variation for *Homo sapiens* must now be extended to five, if not more.

Of course it is quite true that the mandible under discussion is about four thousand or so years old and there is some slight possibility that this amount of multiplicity may have disappeared during the course of this interval of time. Naturally, this point can only be settled by further and thorough investigations. Nevertheless, it is still of great interest, as it indicates that the relatively small amount of variation in the number of foramina mentalia of recent man may still range, or at least has ranged until recently, up to five.

The comparative data given above indicate that the multiplicity of foramina mentalia is a primitive feature for the hominids, and that during the course of human evolution there has been a tendency to reduce the number of the foramina. This tendency appears to have culminated in recent man, most of whom have only one single foramen, with a relatively small amount of variation.

[1] Weidenreich, F., *Palæontologia Sinica*, D, **7**, Fasc. 3 (1936).
[2] Schulz, H. E., *Z. Morphol. u. Anthropol.*, **32** (1933).
[3] Martin, R., "Lehrbuch der Anthropologie", **2** (1928).
[4] Hrdlička, A., Smithsonian Misc. Coll., **83** (1930).
[5] McCown, T. D., and Keith, Sir A., "The Stone Age of Mount Carmel", **2** (1939).

# SCIENTIFIC MAN-POWER IN BRITAIN

THE report of the Committee on Scientific Man-Power*, appointed by the Lord President of the Council on December 9, 1945, under Sir Alan Barlow as chairman, "to consider the policies which should govern the use and development of our scientific man-power and resources during the next ten years", points out that the problem falls into two distinct parts. The immediate tasks are the return of qualified men of science from the Forces to civil life and the civilian occupations in which they have been serving the Forces; to guide them into peace-time occupations according to the needs of reconstruction; and to make good the physical damage which war has inflicted on the universities and research establishments. The longer-term problem is the provision of sufficient qualified men of science to meet the nation's requirements during the reconstruction period and after. In neither respect is a narrow view taken of the field of activity of scientific workers: the Committee believes that much benefit would result from the wide diffusion of scientific knowledge and scientific methods through all spheres of activity. Moreover, since the Committee is satisfied that the demand for scientific workers over the next few years will exceed the possible supply both as a whole and in each major branch of science, it has not attempted to deal with the separate needs for each branch of science.

Dealing first with the immediate problem, the Committee believes that the procedure for expediting the return of scientific men to civil life is adequate, and it has no improvements to recommend. It is satisfied that military commanders on the spot are not exercising unreasonably their power to retain a man on grounds of military necessity. It emphasizes the vital function of the Appointments Department of the Ministry of Labour and National Service, saying that the fullest possible use should be made of its facilities. Since, moreover, the scientific man in industry is most fruitfully employed as a member of a balanced team of men of science, engineers, technical assistants and other ancillary staff, where the shortage of man-power is almost as acute as among scientific workers themselves, applications for the release of experienced assistants under Class B should be considered sympathetically where it can be shown that the work of a scientific worker will be held up if release is not granted. Everything possible should be done to meet the immediate needs of the universities for accommodation, particularly of those that have suffered war damage.

The longer-term problem occupies the bulk of the report, and the Committee's analysis of the supply and demand situation leads to the conclusion that it is unlikely that the nation has at its disposal to-day more than 55,000 qualified scientific workers, whereas a minimum demand of about 70,000 in Great Britain itself and in the Colonial services, including 30,000 teachers, is predicted for 1950. On the expansion envisaged in the returns furnished by the universities to the University Grants Committee, it is unlikely that the trained scientific man-power available in 1950 will exceed 60,000, and it may be no more than 55,000. Review of demand over a five-year period is, of course, inadequate as a basis for recommendations, where three years is the minimum period of training; but taking all known factors into account, the Committee estimates that by 1955 the demand for scientific workers will be not less than 90,000, and that under present plans we can expect no more than 64,000 to be available. Accordingly, it is essential that the output of graduates in science should be increased very much above the level of expansion at present contemplated by the universities of Britain: the immediate aim should be to double the present output, giving us approximately 5,000 recruits every year at the earliest possible moment.

Turning next to this question of doubling the output of scientific workers, the Committee is satisfied that there is an ample reserve of intelligence in Great Britain to allow both a doubling of the university numbers and a simultaneous raising of standards. Only about one in five of the boys and girls who have intelligence equal to that of the best half of the university standards actually reach the universities, and the great majority of the intelligent persons who do not reach the universities are from the elementary schools. Furthermore, even doubling the total student population of British universities would leave the country behind a number of European countries and the United States of America in the relative provision it makes for higher education.

The Committee also supports the recommendation of the Percy Committee on Higher Technological Education that full-time technological courses of university degree standard should be developed at a selected number of technical colleges, and it supports Lord Eustace Percy's opinion that the Government should treat the colleges of technology as a group and develop among them some major university institutions. It also welcomes the stress laid on the provision of post-graduate research courses in such colleges and any arrangements to raise the currency of technological qualifications. The universities must also recognize their responsibility for training a high proportion of first-class technologists, and expansion in the output of graduates should not be less proportionately in technology than in pure science. Urgent consideration should be given to the development of two or three institutes of technology, preferably in university cities, to maintain the highest possible standards of post-graduate study and research. Equally, the Committee deprecates any attempt to meet the increased demand for scientific men and technologists at the expense of other subjects, or to give any preference to science students over arts students in such matters as military service. It attaches very great importance to the atmosphere of an association of men and women which takes all knowledge as its province and in which all branches of learning flourish in harmony.

Reviewing next the capacity to expand of the universities of Britain, the Committee stresses the great importance of the universities being assured in future of adequate and continuing assistance from the Exchequer towards any project for which good cause is shown. It is confident that even in the next few years there will be no lack of trained students to fill the expanding universities; but the Committee comments trenchantly on the inadequacy of both available buildings and the supply of suitable teachers. In regard to the former, it suggests that the possibility of using neighbouring country houses or vacated military camps as temporary annexes might be explored or the shift system extended to make fuller use of lecture rooms and laboratories.

* Report of the Committee on Scientific Man-Power. (Cmd. 6824.) (London: H.M. Stationery Office, 1946.) 6d.

In regard to staff, the Committee is not convinced that if the universities started a vigorous recruiting campaign, an adequate supply of science teachers of sufficient calibre would not be forthcoming. It recommends that the universities should make a comprehensive survey of their staff requirements in the light of the expansion proposed, that all university vacancies should be notified as a matter of routine to the Appointments Department of the Ministry of Labour, and that the universities should consider the possibility of taking an increased proportion of their staff direct into the lecturer grade. The Committee is opposed to any attempt to increase the student population by adding substantial additional teaching responsibility to the individual members of a faculty: the average teacher should have more and not less opportunity for his own research than he has had in the past

In this belief that, once the urgency and importance of the nation's need for more graduates are widely appreciated, and provided the financial misgivings of the universities are removed, the obstacles to their expansion in the immediate future need not prove insuperable, the Committee considers the problems of individual universities and their response to the idea of expansion. Regretting that neither Oxford nor Cambridge has suggested any permanent expansion in its student body, the Committee considers that these two ancient universities should regard it as a duty to make some contribution towards meeting the nation's requirements, possibly by enlarging some of the smaller of the existing colleges and the foundation of one or more new colleges. There is some scope for expansion in the student population of the University of London, although expansion may involve a policy of decentralization. A really substantial expansion of the English civic universities and the University of Wales depends to a considerable extent on these universities being able to compete with Oxford, Cambridge and London for the limited supply of talented students. The present system tends to concentrate the major proportion of State and county scholars into three universities and is fundamentally bad. The improvement of amenities such as halls of residence is one among many ways in which the civic universities can help themselves, but the educational authorities should consider urgently a revision of the scholarship system.

The existing University Colleges of Nottingham, Southampton, Exeter, Hull and Leicester should be able to make a substantial contribution towards filling the remaining gap and should aim at earning full university status at the earliest possible date. There are also several large centres of population in which new university colleges could profitably be established. The Committee thinks that there is still scope for expansion, though on a smaller scale, in the Scottish universities; but it also suggests that early consideration be given to the foundation of at least one new university which would give to the present generation the opportunity of leaving to posterity a monument of its culture. Finally, touching on the quality of science teaching, the Committee emphasizes its dependence on the quality of research and records its opinion that, as an essential part of any balanced expansion in the science faculties, there should be an expansion in research schools for training purposes apart from the needs of the students, and an increase in the financial grants that are made specifically towards research by university staffs.

When all possible measures have been taken to expand the output of graduates, Great Britain will still be seriously short of scientific workers in 1950, and is unlikely to have an adequate supply by 1955. The Committee incidentally records the view that if the intellectual standard of graduates is not to suffer, science students should be allowed, if they wish and if there is room for them, to complete their full course before doing their period of military service; but it also recommends that some system of priorities should be established to secure the best use of our limited supply of men of science. During the reconstruction period, this order of preference should be, first, teaching and fundamental research; secondly, civil science, both Government and industrial; and thirdly, defence science. It is important, however, to maintain an adequate nucleus of able scientific workers working on the problems of defence, and the order of priority set out should be kept under constant review by the Government. As one means of implementing this order of priority, the attractions of an academic career should be improved. Provision of more secretarial assistance and office machinery for university teachers would not only contribute to this end but also would increase materially the efficiency of the universities. Looking at the position after 1955, the Committee does not think that the universities need fear that expansion of their facilities to provide an output of 3,000 graduates in science each year would leave them with excessive staffs and accommodation once the demand for qualified scientific workers has steadied.

No indication of the cost of implementing these proposals is attempted in the report, but the Committee insists that acceptance of the proposals by the Government must not involve any infringement of the independence of the universities. Such independence, in the Committee's view, is not inconsistent with a greater degree of co-ordination between university policy and the needs of the country than has existed in the past. The Government's instrument in any expansion programme should be the University Grants Committee, which should increasingly concern itself with positive university policy in Britain, and it may be desirable for this purpose to revise its terms of reference and strengthen its machinery.

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# OBITUARIES

## Dr. F. Crowther

Dr. Frank Crowther, chief plant physiologist in the Department of Agriculture of the Sudan Government, died on April 11, at the early age of forty, after a very brief illness, during his first post-war leave.

He was educated at St. Albans School and entered the Imperial College of Science and Technology in 1923, graduating in botany with honours in 1926. The next two years were devoted to research in plant physiology; his work broke new ground, and established the differential manurial response of varieties of barley, and the inheritance of specific efficiencies in the utilization of individual nutritive elements. During this period Dr. Crowther was closely associated with me, and acquired, at first hand, knowledge of the methods of growth analysis which were at that time being developed. In 1928 Dr. Crowther accompanied me to the Sudan, and was appointed as plant physiologist at the Gezira Research Farm soon after his arrival. Work was begun on the analysis of the

factors determining growth and yield of cotton under irrigation, to the completion of which he devoted with great zeal the whole of his life. The technique of field experimentation in the study of interaction of factors, then a new departure in agronomy, was exploited from the outset, and papers on interaction of nitrogen and water supply, and of the four factors, nitrogen, water, sowing date, and spacing, appeared in 1932 and 1934. Appreciation of the importance of establishing experimentally the optimal combination of all controllable factors was a guiding principle, and with this knowledge adjustment of the cultural method was later introduced into large-scale practice on the Gezira Irrigation Scheme.

A challenging fact encountered in the Gezira is the seasonal fluctuation in yield in spite of irrigation and the absence of rain except during the first two months of growth. The elucidation of this problem remained one of the major aims of Crowther's work.

His association with the Sudan was interrupted by a period of three years in Egypt and one year in India, where he applied the same methods of study to cotton and other crops. The work of this period was embodied in eight bulletins of the Royal Agricultural Society and Imperial Chemical Industries, Ltd. Dr. Crowther was therefore in a unique position to study in a comparative way growth and yield of irrigated cotton under very different environments. A detailed analysis of the data for plant development in Egypt and the Sudan appeared as his last publication in 1944.

A characteristic of Dr. Crowther's researches was the persistency with which the work was developed in a logical sequence from theory to field experiment and thence to large-scale practice. The problem presented by the annual fluctuations in yield was attacked in diverse ways. The variation in onset and intensity of rainfall before sowing had been pointed out as a determining factor by Dr. E. M. Crowther in 1926, and under their joint names a full study of this relationship appeared in 1935. This work directed attention to the conditions in the soil during the preceding year of fallow, and eventually resulted in a method of weed control, by which, with the collaboration of the Sudan Plantation Syndicate, spectacular increases in yield on a full commercial scale have been achieved. The most recent development was a study of the root system, which established penetration to the depth of nine feet, and may throw light upon the secular fluctuations in subsoil water and soil nitrate in relation to the later stages of plant development. Exigencies of space forbid discussion of many other aspects of Crowther's work.

Primarily Dr. Crowther was in training and outlook a plant physiologist for whom the study of plant development, in the tradition initiated by Dr. W. L. Balls, held a clue to the analysis and control of plant yield. The successful forecasting of yield only a few days after germination showed the possibilities of utilizing such studies. Crowther developed to the full other and varied capacities. As agronomist, and organiser of field experimentation on a vast scale, Crowther's achievements were outstanding; indeed they may be cited as a supreme example of the fertile union of pure and applied science. He displayed a mastery in the planning of field experiments, and personally trained and led a host of enthusiastic local assistants engaged in carrying them out. Unsparingly he dedicated his energy to the furtherance of tropical agriculture, and the scope and importance of the results obtained stand as a permanent memorial to his work. Plant physiology, properly applied, has in Crowther's work demonstrably rendered service to practical agriculture. It is fortunate that one of Crowther's last labours was the preparation of a critical résumé of the agricultural investigations in the Sudan, to the development of which he contributed so much. The premature termination of Dr. Crowther's labours, with the promise of great advances yet unrealized, is indeed an irreparable loss to agricultural science; and his untimely death a lamentable personal grief to me.

F. G. Gregory

## Prof. J. Ernest S. Frazer

By the death on April 15 of Prof. J. Ernest S. Frazer, British anatomy has lost an anatomist of great charm and distinction. He had been suffering from ill-health since his retirement in 1940, and his death took place suddenly in London.

Prof. Frazer was born in London in 1870 and was educated at Dulwich College and St. Bartholomew's Hospital. He qualified M.R.C.S., L.R.C.P. in 1891. For several years thereafter he devoted himself to clinical work in various hospitals in London and the Provinces. He obtained his F.R.C.S. in 1898 and his D.Sc. London in 1932. It was not until after a severe illness resulting from an infection at a post-mortem that he decided to adopt anatomy as a career. His first appointment in anatomy was demonstrator in St. George's Hospital in 1900. From there he moved to King's College in 1905. In 1911 he was appointed lecturer and later (in 1914) professor of anatomy in St. Mary's Hospital Medical College. Generations of students at St. Mary's are indebted to him for his stimulating and instructive teaching.

Frazer made a very definite contribution to the subject of embryology. This did not always receive from contemporaries the recognition it rightly deserved. His "Manual of Embryology", first published in 1931 and now in its second edition, afforded him the opportunity of bringing together his original observations and interpretations which had been recorded in numerous papers published in the *Journal of Anatomy*. His text-book "The Anatomy of the Human Skeleton", first published in 1914 and now in its fourth edition, not only gave a detailed and accurate account of the bones of the skeleton but also it 'dressed' the skeleton with ligaments and muscles. He was also editor of Buchanan's *Manual of Anatomy* and *Manual of Practical Anatomy*.

Prof. Frazer was elected to the Hunterian professorship of the Royal College of Surgeons in 1915–16 and to the Harveian lectureship in 1924.

In 1935 he was elected president of the Anatomical Society of Great Britain and Ireland. Many of us recall with pleasure the courteous way in which he conducted the meetings during his term as president.

W. J. H.

We regret to announce the following deaths:

Dr. H. G. Earle, director of the Henry Lester Institute of Medical Research and Preventive Medicine, Shanghai, since 1928, on June 5, aged sixty-three.

Mr. Alexander L. Howard, author of "A Manual of Timbers of the World", on June 5, aged eighty-three.

Dr. Howard W. Starkweather, who was in charge of research in the fields of elastomers and fine chemicals at the Jackson Laboratory of E. I. du Pont de Nemours and Co., on May 18, aged fifty-five.

# NEWS and VIEWS

## Central Advisory Water Committee

THE Minister of Health, in exercise of the powers conferred on him by Section 2 of the Water Act, 1945, has appointed the following to constitute the Central Advisory Water Committee: Mr. Henry Berry, M.P., chairman, Metropolitan Water Board; Col. F. Hibbert, M.P., chief engineer, Liverpool Corporation Waterworks; Mr. Philip Porteous, managing director, Cambridge University and Town Waterworks Company; Alderman N. F. S. Winter, Halifax Town Council; Sir Wynne Cemlyn-Jones, Anglesey County Council; Mr. J. Chaston, town clerk, Kettering; Sir Robert Doncaster, representing the Rural District Councils Association; Mr. J. E. James, Imperial Chemical Industries, Ltd.; Mr. H. Johnson, secretary, Bleachers Association, Ltd.; Mr. S. R. Hobday, director and general manager, Lee Conservancy Board; Mr. M. Kissane, secretary, Manchester Ship Canal Company; Capt. Jocelyn Bray, chairman, Thames Conservancy Board; Mr. G. A. Worth, Soham Internal Drainage Board; Sir Cecil Newman, acting chairman, National Association of Fishery Boards; Mr. J. N. McLean, vice-president, National Farmers' Union; Sir Arthur Heneage; Mrs. E. M. Braddock, M.P.; Mr. D. McAdam Eccles, M.P.; Lord Rae; and Lord Walkden.

The Committee's terms of reference are to advise the Minister of Health, or any other Minister concerned, upon matters connected with the conservation and use of water resources; on the amendment of enactments which relate to, or in any way affect, the conservation or use of water resources or the provision of water supplies; and on any question that may be referred to the Committee by the Minister in connexion with the operation, or proposed amendment, of relevant enactments. It will also consider the operation of any such enactments, and, where it thinks fit, make recommendations for their extension or modification. Any communication concerning the work of the Committee should be addressed to the secretary, Mr. M. R. P. Gregson, at the Ministry of Health.

## Jet-Propelled Tailless Aircraft

FOLLOWING the tailless glider produced by Messrs. Armstrong Whitworth for experimental work leading to high-speed stratosphere flight, Messrs. De Havilland have now completed a similar aircraft, powered with a "Goblin" gas turbine developing about 12,000 h.p. at the speeds of flight attained. The "Goblin" turbo-jet unit is also Messrs. De Havilland's own design. It is the only jet-propelled aircraft with pronounced swept-back wings that has flown up to the present. It is anticipated that speeds up to 675 miles per hour may be reached. The machine is a logical development of the De Havilland jet-propelled "Vampire", which is now in production and supplied to the fighting services.

Mr. Wilmot, Minister of Supply, at a recent Press conference, announced that there are seven types of civil aircraft now being produced in Great Britain for gas turbine propulsion. These correspond to the types suggested to Parliament by the Brabazon Committee. The designing and constructing firms are Messrs. Bristol, Airspeed, Vickers, Handley Page, A. V. Roe, De Havilland and Miles. There are also many R.A.F. and F.A.A. equipment types in the hands of these and other firms. Mr. E. F. Relf, giving the Wilbur Wright Lecture before the Royal Aeronautical Society, said that steps are being taken to try out a new type of wing suitable for this class of aircraft. The wing shape is based upon the idea of deliberately creating a sudden discontinuity of velocity and pressure at suitable sites on the wing surface, and introducing an artificially created suction at these points. This may help in the solution of the problem of overcoming the 'shock stall' at very high speeds.

## Science in Post-Primary Education

A REPORT with this title is the second part of the report published as an interim report in June 1944, by the Association of Women Science Teachers. Whereas the interim report was concerned with post-primary science from eleven to sixteen years, the second report completes the work by consideration of sixth-form science, part-time education in science, the training of teachers, administrative problems and sixteen special topics of a utilitarian nature and of special value and interest to those planning laboratories or running a science department. These two reports, published by John Murray at 1*s.* 3*d.* and 2*s.* net each, should be in the hands of all those whose minds are awake to the vast possibilities of science-teaching within the new Education Act. While stressing the need for less specialization in sixth-form work, the second report considers separately the general scientific education of all sixth-form pupils, the science specialists and those who may best be described as the general group of pupils in the sixth form. It is urged that all sixth-form pupils should meet together once a week to study current affairs, which includes topics of scientific interest as well as those of an economic and political aspect. Arts students will need a special science course of two periods a week, the counterpart of the special English course for the scientists. A suggested time-table for these various groups is given. The work provided in the county colleges, on a basis of one day a week attendance, should cater for pupils with varied aptitudes and attainments. A tentative scheme which recognizes the need for such a variety of science courses is given: flexibility is the key-note. The chapter on the training of teachers urges that good general science courses should be provided for suitable students in the training colleges and that sufficient time should be allowed in teaching practice to acquire a reasonable amount of technical skill. Graduates trained in the university training departments need opportunities for first-hand study of the children they are going to teach.

There are brief but useful references to sizes of classes in a laboratory, to laboratory assistance and to the necessary free time of science teachers. The appendixes should guide many when faced with the problems of planning of a general science syllabus, of equipping a general science laboratory down to the smallest detail, of keeping an eye on the administrators and builders. They should assist the young teacher with concrete help, while keeping the ideals of social general science before him; they should provide a concise reference of many topics to a busy head of department. The chapters on laboratories and adjuncts, on essential equipment, on visual aids, fire precautions and first aid are extremely valuable. The Association of Women Science Teachers has done a good piece of work in publishing so much useful material in convenient form. It is helpful to

know that a further report, adapting the syllabuses in greater detail for use in secondary modern schools of varied types of area, is already in production.

## Fossil Fauna in Norfolk

DISCOVERIES of no little interest to palæontologists and archæologists are reported from Norfolk. During the past winter and early spring, the effects of marine erosion on the cliffs around the coast have been severe, causing much local uneasiness. In compensation, as a result of this tidal action, early quaternary deposits at the base of the cliffs and on the foreshore have been laid bare to an exceptional degree. At Mundesley, in particular, the Cromer Forest Bed is exposed more extensively than has occurred for a very long period and a number of discoveries have followed. Early in May, a fossil bone protruding at the base of the cliff was observed by Mr. E. A. Livermore of Mundesley. On extraction, this proved to be the major portion, a little more than three feet in length, of an elephant's tusk. It has since been identified as belonging to the extinct straight-tusked elephant, *Elephas antiquus*. A few days later, Mr. Livermore also recovered from close to the position of his first find part of a tooth, about six inches in length, of an elephant of the same species. Further discoveries were two fragments of bone, the tips of an elephant's femur and tibia respectively. A remarkable tooth, which belongs to *E. meridionalis*, also from the Cromer Forest bed at Mundesley, has been found by Mr. A. Savin of Cromer. It is complete, and weighs twenty-five pounds. With one exception, a tooth of twenty-six pounds, it is said to be the largest *meridionalis* tooth recorded.

The estuarine deposits of the Cromer Forest bed series at Mundesley, it will be remembered, have yielded in the past a rich fossil mammalian fauna, of which a large proportion, more than 70 per cent, belongs to extinct species. They include, in addition to the two elephants mentioned above, *Hyæna striata*, *Rhinoceros etruscus*, the sabre-toothed tiger (*Machærodus latidens*), which is also recorded from Kent's Cavern, Torquay, and the hippopotamus, which appears here for the first time. As a whole, the mammalian fauna is from a warm-temperate climate, whereas the marine is regarded as indigenous and on the whole is arctic. In relation to man, the Cromer Forest Bed equates with the developed Abbevillian (Chellean) industry.

## Institute of Fuel

THOSE who can look back to the beginning of the century cannot fail to be impressed by the changes which have taken place in connexion with the supply of fuel. The excellent—and what now appears to be cheap—coal was abundant: cost of fuel might appear to be a negligible factor in the production of manufactured products. Advocates of fuel saving or smoke abatement were voices crying in the wilderness: their messages were of no concern to the State and even unwelcome to the fuel industries. Two great wars—especially the last one—have produced the great change, revealed nowhere more clearly than in the development of the Institute of Fuel. On April 17, Dr. E. W. Smith, in his presidential address, said that the Institute, which in 1939 after a modest life of twelve years had gathered about one thousand members, had by 1946 reached in numbers about two thousand six hundred. This is a measure of the growing interest by the technologists themselves. It is a measure of the rising importance of fuel conservation for a long time to come. The Institute is devoting much attention to the spread of better understanding about fuel and its utilisation. Dr. Smith said that this should begin with children, who should be taught early at school the elements of the science of combustion, so that they are already 'fuel conscious' before embarking on the business of life.

The Institute of Fuel hopes in the near future to reach the dignity of a chartered body. In addition to the publication of an important technical journal, the Institute has started a scheme to encourage the public education in fuel technology in all branches—from the operative to the research worker. In this, the Institute is in co-operation with the Ministry of Fuel and Power, and, on the examination side, with the City and Guilds Institute. All this activity can be understood if it be remembered that, in future, domestic arrangements must become less primitive and more efficient. Recognition of the essential worth of fuel as a national possession must assert an influence in all walks of life.

## Association of Special Libraries and Information Bureaux: Northern Branch

AT the conference in Manchester on May 8 arranged by the Association of Special Libraries and Information Bureaux to discuss industrial information services, a statement regarding the proposed formation of a Northern Branch of the Association was made by Mr. R. Brightman, librarian, Imperial Chemical Industries, Ltd., Dyestuffs Division, and chairman of the provisional committee formed early in the year for that purpose. The desire of many members of the Association for regular meetings in the northern area, as well as for a conference in that area, has been frequently expressed at recent annual conferences; and in view of the fact that a heavy proportion of the industrial membership of the Association is concentrated in an area lying north and west of a line drawn roughly from the Humber through Nottingham, Leicester, Birmingham to Bristol, the Committee has in mind something much wider than the mere revival of the Lancashire and Cheshire Branch which functioned during the period 1931–36. The committee contemplates, instead of a series of meetings in any one town, a programme of meetings in different centres, preferably not more than a couple of meetings in the year, which might be arranged in such places as Manchester, Liverpool, Harrogate, Keighley, Nottingham, etc., and cover subjects meeting the needs of the works' librarian in particular. It is hoped that the Branch will keep in close touch with such developments as the lectures on classification and cataloguing arranged at the College of Technology, Manchester, by the North-Western Branch of the Library Association, and other developments which may provide training for those entering on a career of librarianship in industry.

A meeting to constitute such a Northern Branch will be held at the Manchester Central Library, Peter Square, on June 27 at 3 p.m. Mr. R. Brightman will preside, and after the formal business and election of a committee, Miss M. Exley, librarian of the Commercial, Science and Technological Libraries, Sheffield, will speak on "Co-operation between Libraries in the Northern Region". The provisional committee, in retiring, is suggesting a further meeting of the Branch at Liverpool in the autumn and a one-day conference at Sheffield in the spring of 1947. The honorary secretary is Miss L. Wolff, Hexagon House, Blackley, Manchester.

### Philips Research Reports

During the period of occupation of the Netherlands by the Germans, much of the scientific work at the N. V. Philips Gloeilampenfabrieken at Eindhoven had, for obvious reasons, to be interrupted temporarily; but, in spite of all the difficulties, it never completely ceased. Now that the War is ended and the occupied countries have been liberated, Messrs. Philips Lamps Ltd. are anxious to restore the contact between the Netherlands and the rest of the world and to promote scientific co-operation. They hope to resume the publication of *Philips Technical Review*, which had to be stopped during the occupation, and they announce the introduction of a new scientific journal, *Philips Research Reports*. The *Review* is to contain, as formerly, descriptions of Philips' products and their applications, being primarily intended for engineers and technically minded users of the firm's products. The *Research Reports* will be devoted to the results of pure research work undertaken, in many different fields, in the Company's research laboratories. The journal is to be issued bi-monthly, the six issues in one year forming a volume of about 480 pages and the first volume to be completed in 1946. The first issue is dedicated "to the memory of the firm's employees who lost their lives owing to acts of war and those who fell victim to German oppression in the years 1940–1945". The issue contains four theoretical papers dealing with the elastic after-effect and diffusion of carbon in alpha-iron, positive grid-current, the stability of lyophobic colloids, and the electric field of a vertical dipole. The price of the journal is 4*s*. a copy or one guinea a year; copies may be obtained in Britain from Philips Lamps Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

### H. K. Lewis & Co., Ltd.

In an attractively produced book entitled "Lewis's 1844–1944. A Brief Account of a Century's Work" (London: H. K. Lewis and Co., Ltd., 1945), Messrs. H. K. Lewis give not only an excellent example of their high standard of book production, but also a fascinating history of the foundation and development of a publishing house which has attained a unique position in the intellectual life of Great Britain and other countries. The qualities of Lewis's well-known Lending Library have already been noted in *Nature* (155, 710; 1945); but the history of that library and of the publishing and book-selling business which accompanies it are less well known. It deserved to be told; and this book, which also gives much information about the men who gradually created the services which so many medical and scientific men now enjoy, will be read with great interest. "It is hoped," says H. L. J. in his preface, "that the effort to avoid mere advertisement has been successful." That sentence is conceived in the spirit which has inspired the directors and staff of Lewis's since Henry King Lewis, in 1843 or 1844, first infused it into the small book-selling and stationery business at 15 Gower Street, the starting point of the modern Lewis's. It is interesting to learn that, in those days, readers of the *Lancet* who did not wish to keep that journal paid rather more than half the subscription to the *Lancet* and, when they had read the journal, gave it to Lewis, who displayed an advertisement, "Second Reading of the *Lancet* to Let"; in this way 'second readers' were obtained, who paid the balance of the subscription. This practice is worthy of consideration nowadays, when it is often difficult to obtain sufficient copies of important journals.

From its earliest days Lewis's Library was used by distinguished medical men, and it is clear that the influence of Henry King Lewis, whose wide interests and remarkable qualities are the subject of a chapter of this book, has never faded. The history of the development of the original business to include the publishing of important books and of journals like the *Clinical Journal* and the *British Journal of Experimental Pathology* is illustrated by portraits of the many distinguished men whose books have been published by Lewis's or who have been associated with the firm in other ways. Altogether the record here presented is one of which the present directors and staff have very good reason to be proud.

### Eighteenth Century Russian Explorations in the Northern Pacific

The All-Union Geographical Society of the U.S.S.R. (Moscow) has published a small handsome volume, dated 1944, containing some newly discovered documents relating to Russian explorations and discoveries in the Pacific Ocean and North America during the eighteenth and nineteenth centuries. The first part of this book contains reports, dated 1762 and 1764, by merchant-adventurers on the Aleutian Islands. The second part contains reports written by the members of the Russian–American Company during the period 1785–90, together with reports made by the governor-general of Siberia to the Empress Catherine on the state of trade and exploration of the Aleutian Islands and Alaska, or 'Russian America' as they were known in Russia prior to 1867. The third part consists of a diary written by N. I. Korobytzyn, a clerk of the Russian-American Company, during the first Russian round-the-world cruise of 1803–6. This diary, although written by a semi-educated man, presents a very vivid picture of the Pacific Ocean islands and of the trading conditions in Russian America and China. The book, which is entirely in Russian, is edited by A. I. Andreev, and it is provided with numerous illustrations.

### Visual Education and the New Teacher

There is plenty of food for thought in the stimulating pamphlet under the above title prepared by Mr. G. P. Meredith, of the Visual Education Centre, Exeter (Pp. 64. 2*s*. 6*d*.), and it is to be hoped that some action may result from it. "The problem before us is the fate of the teacher under the impact of the new educational media and their ultimate effect on education." Materials and curriculum are carefully surveyed, and a plea made for the separation of teachers' functions according to their talents (for example, for academic work, class teaching, organisation, etc.) rather than as form-master or specialist. The author is concrete in his suggestions, and believes that a reasonable Dalton plan can enable the multilateral principle to be retained within one school, without the rigid 'stream' system referred to in the Spens Report. He asks, "Is the implementation of the famous 1944 Act so imperiously in motion that the unnatural barriers between grammar, modern and technical schools are unbreakable?" Mr. Meredith maintains that the new educational media, including radio, and later, television, can only reach their full potentiality if the teacher's status is decisively raised, and by this he means not simply a matter

of an increase in salary, but a revaluation of the teacher's functions.

## Inheritance of Human Characters

It is fascinating to examine our friends for hereditary characters which are, so far as we know, innocuous. Taste blindness, position of thumbs when the hands are clasped, and beating time with the left or the right foot are among the characters which have previously been reported as being inherited. K. A. Stiles and J. Schalck (*J. Hered.*, **36**, 211 ; 1945) add another character for such analysis. They show that the curvature of the forefinger towards the ulnar side is inherited, probably as a dominant. It may show unilateral expression, but sometimes involves both hands and more than one finger. It is not pathological. A further inherited character is olfactory blindness, tested through three generations by R. C. Mainland (*J. Hered.*, **36**, 144 ; 1945). The inheritance is probably by an autosomal dominant gene. The affected individual cannot smell oil of cloves, lysol, oil of cedarwood, amyl propionate and oil of annise ; he could not distinguish between sour and sweet chocolate or between cloves and cinnamon. The phenyl-thio-carbamide test was normal.

## A Human Mosaic

M. Zlotnikoff (*J. Hered.*, **36**, 136 ; 1945) has described a remarkable case of a woman who, in her own words, describes herself as a new species arising from a mutation in the two blastomere stage or as a blastomatous variation. The left side of the body is brown, café au lait, or crimson in colour ; the right side is completely normal. The median line is strictly delimiting. The left side is bald, whereas the right side is normal. Eye colour is grey on the right and chestnut on the left. Hair colour is red and chestnut respectively. Perspiration and reactions to pilocarpine and atropine are normal on the left, but on the right side there was a noticeable lack of reaction. The blood pressure difference rose to 25 mm.

## The Kamerlingh Onnes Laboratory

Since May 1940 the distribution of the communications of the Kamerlingh Onnes Laboratory of the University of Leyden has been restricted to the Netherlands ; but a general distribution has now been resumed. So far Nos. 257 to 260 and Supplements 87 to 90 inclusive have appeared, containing reprints of papers published mainly in *Physica* during the years 1939–41. There are several papers by W. H. Keesom and co-workers dealing with the properties of liquid helium, and with specific heats at low temperatures. W. J. de Haas, H. B. G. Casimir and others have investigated the thermal conductivity of lead, specific heats at low temperatures, adiabatic demagnetization and the magnetic properties of several substances. There are also four papers by Jean Becquerel describing experiments on magnetic rotatory power.

## Conference on Pulverized Fuel

The Institute of Fuel is arranging a Conference on Pulverized Fuel to take place in May 1947. The object is to collect up-to-date information on the preparation and use of pulverized fuel, including its advantages and disadvantages compared with other forms of fuel. It is hoped to cover the whole field, including steam raising, cement kilns, metallurgical and other furnaces, and details of developments in pulverized fuel practice throughout the world. The aim is to make available independent authoritative information on all aspects of pulverized fuel production and firing for the guidance of users and potential users of the system, and through the experience of present users to assist manufacturers in the development of design of pulverized fuel equipment. The Conference will also provide useful authoritative information for the use of the Ministry of Fuel and Power and the National Coal Board in their deliberations upon the most efficient preparation of coal for the market. It will also indicate problems to which research in this field might be directed with advantage, although the primary aim of the Conference is to deal with essentially practical problems in the use of pulverized fuel.

## University of Glasgow : Appointments

Dr. J. C. Speakman, formerly lecturer in chemistry at the University of Sheffield, who has been appointed lecturer in chemistry at the University of Glasgow, took up his new duties at the beginning of the present term. Messrs. F. D. Gunstone, of the University of Liverpool, and R. I. Reed, of University College, London, have been appointed to junior lectureships in chemistry as from the beginning of next session. Dr. G. M. Badger and Dr. J. D. P. Graham have taken up appointments as I.C.I. research fellows at Glasgow, in chemistry and pharmacology, respectively. Dr. Badger, who is an Australian, served in the Royal Navy during the War, and Dr. Graham served in the Royal Army Medical Corps.

## Announcements

Messrs. E. R. Watts and Son, Ltd., announce that they have acquired the business of Messrs. James Swift and Son, Ltd. The connexion between these two companies dates back over a hundred years, when Mr. Edwin Watts, founder of E. R. Watts and Son, Ltd., and Mr. James Swift, founder of James Swift and Son, Ltd., were both apprenticed at the mathematical instrument-making firm of Swaine's in the Waterloo Road, London. The bond of friendship so formed was maintained between the two families until the untimely deaths of Mr. Mansell James Swift, and his son, Mr. Mansell Powell John Swift, both in October 1942. Messrs. James Swift and Son, Ltd., will continue to trade under their own name, but it is hoped that the production facilities of Messrs. Watts will enable them to play their part in satisfying the need for microscopes in the next few years.

Vol. 2 of the Transactions of the All-Union Conference on Analytical Chemistry (Moscow : Acad. Sci. U.S.S.R. Section of Chemical Sciences, 1943) contains a number of papers of interest to analytical chemists. Each article deals with a special problem, and new methods and apparatus are discussed. The principal subjects of papers are : analysis of ferro-alloys, spectroscopic analysis, photoelectric analysis, determination of germanium in coal ash, and polarographic methods as applied to various substances.

Erratum. In the heading of the table accompanying the communication entitled "Effect of Heat on Wool, Cotton and Nylon", *Nature* of June 1, p. 735, for "150° F." read "150° C.".

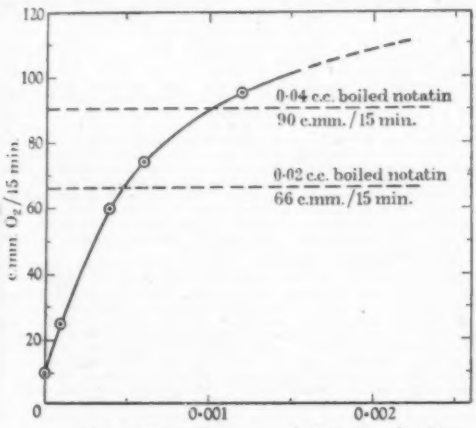
# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Prosthetic Group of Glucose Oxidase (Notatin)

GLUCOSE oxidase was discovered by Müller[1,2] in *Aspergillus niger* and *Penicillium glaucum*. He found that this enzyme catalyses the oxidation of glucose to gluconic acid by means of molecular oxygen, and that at a much slower rate it also oxidizes mannose and galactose but not other sugars. The activity of the enzyme was found by him not to be affected by cyanide. The enzyme was reinvestigated by Franke and Lorenz[3] and by Franke and Deffner[4] who, working with a more purified enzyme preparation, demonstrated that during the catalytic oxidation of glucose to gluconic acid oxygen is reduced to hydrogen peroxide. They found also a certain proportionality between the activities of different preparations and their flavin content, and concluded that the enzyme must be a flavoprotein. More recently, Coulthard, Michaelis, Short, Sykes, Skrimshire, Standfast, Birkinshaw and Raistrick[5], while investigating the antibacterial properties developing in culture media of *Penicillium notatum*, were able to isolate a substance described by them as 'notatin'. They identified this substance as glucose oxidase and showed that the marked antibacterial property which it exhibits in presence of glucose and air is due to hydrogen peroxide produced by the reduction of atmospheric oxygen. They isolated and purified the enzyme on a large scale and obtained a product which can be considered as pure glucose oxidase. This enabled them to re-determine its properties and to establish its flavoprotein nature. They did not, however, determine the exact structure of its prosthetic group, although they suggested that it "could readily be determined whether notatin is of alloxazine-adenine-dinucleotide type by testing it for enzyme activity in the *d*-amino acid oxidase system".

Having a supply of notatin, kindly put at our disposal by Prof. Raistrick and Dr. Birkinshaw, we were able to carry out the experiment suggested in the above remark. For this purpose *d*-amino-acid oxidase was prepared, and the protein of the enzyme was separated from its prosthetic group, the alloxazine adenine dinucleotide, according to the method devised by Negelein and Brömel[6]. The enzyme was then reconstructed from definite amounts of its free protein (fraction *B* of Negelein and Brömel), to which were added different quantities of a standard solution of alloxazine adenine dinucleotide containing 0·65 mgm. riboflavine phosphate per c.c., and the catalytic activities of the mixtures were estimated manometrically by the rates of oxidation of *dl*-alanine in *M*/15 pyrophosphate buffer, pH 8·3 at 39° C. in presence of catalase. The results of these experiments are represented in the form of the accompanying graph showing the relationship between the catalytic activity of the reconstructed system and the amounts of dinucleotide added to the protein component of the enzyme.




RATES OF OXYGEN UPTAKE OBTAINED ON ADDING VARIOUS AMOUNTS OF ALLOXAZINE ADENINE DINUCLEOTIDE OR OF BOILED NOTATIN TO THE SYSTEM: *d*-AMINO-ACID OXIDASE PROTEIN, *dl*-ALANINE AND CATALASE

STANDARD ALLOXAZINE ADENINE DINUCLEOTIDE FOR CALIBRATION (CIRCLES) CONTAINED 0·65 MGM. RIBOFLAVINE PHOSPHATE/C.C. $T = 39°$. *M*/15 PYROPHOSPHATE BUFFER, pH 8·3

Having determined this relationship, the activity of the amino-acid oxidase protein was tested, under exactly the same conditions, with the prosthetic group of 'notatin' instead of the standard solution of alloxazine adenine dinucleotide. For this purpose a solution of notatin in water containing 2·77 mgm./c.c. was heated at 100° for 15 minutes and cooled. The addition of 0·02 c.c. and 0·04 c.c. of this solution to the above oxidizing system brought the amino-acid oxidase activity to the same level as would the addition of 0·00049 and 0·00102 c.c. respectively of the standard solution of alloxazine adenine dinucleotide (see graph). This shows that 1 c.c. boiled solution containing 2·77 mgm. notatin is equivalent to 0·025 c.c. of the standard solution of alloxazine adenine dinucleotide or to 0·01625 mgm. riboflavine phosphate. The sample of notatin tested contains, therefore, 0·59 per cent of riboflavine phosphate. If we assume that the content of riboflavin in pure notatin is the same as in pure diaphorase[7], namely, 0·66 per cent, the notatin preparation would be 90 per cent pure. Moreover, the optical density of a 1 per cent solution of notatin at 451 mμ determined spectrophotometrically in a 1 cm. layer was found to be 1·33, whereas the value for a pure flavoprotein[8,9] is given as 1·54, which indicates that the purity of the sample examined was about 87 per cent. All this clearly demonstrates that the active or prosthetic group of glucose oxidase or notatin is the alloxazine adenine dinucleotide. On addition of glucose to the enzyme, its characteristic yellow colour is rapidly discharged[8] owing to the reduction of the alloxazine ring. On shaking the mixture with air, the alloxazine ring is re-oxidized and the yellow colour of the enzyme reappears.

The purified enzyme in the form of notatin has a very high affinity for glucose, the Michaelis constant *Km* being 0·0042 *M* at 39° C. and pH 5·6. It may be added that the intact glucose oxidase, unlike diaphorase, shows no fluorescence in ultra-violet light, but the characteristic green fluorescence of the free dinucleotide appears on denaturation of the enzyme protein.

We are greatly indebted to Dr. G. Weber for supplying a standardized solution of the free dinucleotide.

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E. F. HARTREE

Molteno Institute,
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May 16.

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[2] Müller, D., *Ergeb. Enzymforsch.*, **5**, 259 (1936).
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## Fibrinolysis in Peptone and Anaphylactic Shock in the Dog

FIBRINOLYSIS in peptone and anaphylactic shock can be demonstrated either directly, by estimation of fibrinogen in samples taken after the injection of the respective agent, or by adding protamine in order to counteract the effect of the heparin which is discharged into the blood stream. We have shown[1] that even the addition of an excess of a powerful preparation of human thrombin is unable to correct the decrease in fibrinogen, which can be estimated by the method of Cullen and Van Slyke[2]. Since thrombin was able to correct the inhibitory effect of heparin added in amounts such as those appearing in anaphylactic shock, we conclude that a drop in fibrinogen actually occurs during anaphylactic and peptone shock. Moreover, in the case of peptone shock, fibrinolysis can be directly observed, since in several cases the blood clots very quickly and the coagulum redissolves after a few hours. Apparently, Nolf[3] was the first to describe this fibrinolytic effect as occurring after peptone injection, in animals in which the liver had been removed or the circulation reduced to the upper part of the body, by ligaturing the thoracic aorta and inferior vena cava, just above the diaphragm. It is now clear that in Nolf's experiments, the removal of the liver prevented the discharge of heparin, since it has been proved that heparin comes from the liver in peptone and anaphylactic shock[4].

Following a suggestion by Dr. L. B. Jaques of Toronto[5], we have used protamine to block the anti-coagulant effect of heparin. When a suitable amount of protamine is added to blood samples taken at the height of peptone and anaphylactic shock, coagulation occurs and, after a few hours, partial or complete fibrinolysis can be observed, especially in the tubes containing the largest amounts of protamine. This 'fibrinolytic protamine test' can be set up by taking samples before and after the injection of the shocking agent and pipetting 0·5 ml. of blood into each tube of a series containing increasing amounts of protamine in 0·5 ml. of saline. The tube in which coagulation first occurs indicates the amount of heparin present, since there is a quantitative relationship between the amount of heparin present and the amount of protamine added to the tube which clots first[4]. If the tubes are placed in a thermostat, at 39°, after 10–15 minutes the beginning of redissolution of the coagulum is already apparent. In most cases, total redissolution can be seen in several tubes after forty minutes to an hour, and the phenomenon is fully developed after three hours at 39°.

As shown in the typical experiment presented in the accompanying table, fibrinolysis is a maximum after a first injection of peptone, moderate after a second injection and absent after a third or fourth injection of the same dose of peptone. A very similar phenomenon can be observed when horse serum is given intravenously to a dog previously sensitized to it (anaphylactic shock). After the first shocking injection there occurs a very conspicuous fibrinolysis. After recovery of the animal, a new injection of the serum produces no shock and no fibrinolysis occurs. On the other hand, when a sensitized animal receives a first dose of peptone which produces moderate shock, with fibrinolysis, sometimes it becomes refractory to further injections of the serum to which it had been sensitized. When this occurs, fibrinolysis cannot be observed after the injection of the antigen.

Hence we conclude that this fibrinolytic effect is closely concerned with the mechanism of production of peptone and anaphylactic shock, and that desensitization (refractoriness) may depend either upon the exhaustion of the mechanism leading to fibrinolysis or upon the discharge of an anti-fibrinolytic factor which would block the initial wave of fibrinolysis and prevent the appearance of a further fibrinolytic effect after the second injection of the agent. We are now actively

ESTIMATION OF HEPARIN AND FIBRINOLYSIS IN THE BLOOD SAMPLES OF A DOG SUBJECTED TO PEPTONE SHOCK

| Amounts of protamine added (γ/0·5 ml.) | | Blood samples after several intervals following the injection of 300 mgm. of peptone per kilo of body-weight: | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Before | 1st injection | | | | 2nd injection | | 3rd injection |
| | | I | II | III | IV | VI | VII | VIII | IX |
| 100 | clot. time (min.) | 10 | 12 | 13 | 10 | 8 | 20 | 15 | 10 |
| | fibrinolysis | 0 | ++++ | ++++ | ++++ | 0 | ++++ | 0 | 0 |
| 50 | clot. time (min.) | 8 | 11 | 12 | 8 | 7 | 14 | 9 | 10 |
| | fibrinolysis | 0 | +++ | ++++ | +++ | 0 | ++ | 0 | 0 |
| 25 | clot. time (min.) | 5 | 8 | 10 | 7 | 9 | 13 | 7 | 8 |
| | fibrinolysis | 0 | + | +++ | +++ | 0 | 0 | 0 | 0 |
| 10 | clot. time (min.) | 5 | 6 | 11 | 9 | 10 | 12 | 5 | 5 |
| | fibrinolysis | 0 | ++ | +++ | 0 | 0 | 0 | 0 | 0 |
| 0 | clot. time (min.) | 4 | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ | ∞ |
| | fibrinolysis | 0 | — | — | — | — | — | — | — |

++++, Total fibrinolysis in less than 1 hr.; +++, total fibrinolysis in less than 2 hr.; ++, total fibrinolysis in less than 3 hr.; +, partial fibrinolysis; 0, no fibrinolysis for at least 24 hours. The minimum clotting time indicates the optimum amount of protamine and therefore the amount of heparin present in the blood samples.

engaged in testing those two possibilities, since they certainly will have a bearing upon the problem of counteracting anaphylactic and allergic manifestations. Another conclusion can be drawn from those experiments: since fibrinolysis strongly suggests the interaction of a proteolytic ferment[5,6], it is quite probable that activation of plasma trypsin takes part in the production of those modalities of shock.

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## Histochemical Demonstration of Acid Polysaccharides in Animal Tissues

RECENT work on the acid polysaccharides occurring in the animal body and on enzymes, such as hyaluronidase, which hydrolyse them, has emphasized the need for more specific methods for their histological demonstration.

Unsuccessful attempts were made to modify the usual methods of fixation and staining with basic dyes such as toluidine blue. Aqueous fixatives, such as formaldehyde, which act chiefly as protein fixatives, do not fix hyaluronic acid, which dissolves out into the solution and into the subsequent washing water. It is necessary to use a dehydrating fixative such as Carnoy's fluid in order to preserve the polysaccharide *in situ*. Although toluidine blue is satisfactory for sulphated polysaccharides, such as chondroitin sulphate, which stain metachromatically, it is of less value for hyaluronic acid and similar polysaccharides, which probably contain no sulphate and do not stain metachromatically. It is difficult to differentiate a polysaccharide which stains purple-blue from other tissues which stain similarly.

Preliminary experiments have indicated that the method described below may be of value; a thorough investigation has not been practicable, but it is hoped that other workers may find the description useful. In principle, the method depends upon the treatment of the tissue with a suitable fixative; after dehydration and the preparation of a paraffin block, sections are cut, mounted and then treated with an acid solution of ferric hydroxide. The iron combines with acid polysaccharides but not with neutral polysaccharides or proteins. The combined iron is then demonstrated as prussian blue by treatment with hydrochloric acid and potassium ferrocyanide. If the sections are counterstained with a red dye such as fuchsin, the acid polysaccharides are stained blue against a red background of other tissue structures.

The detailed method is as follows: (1) Pieces of tissue not more than 3–4 mm. thick in Carnoy's fluid (absolute alcohol, 6 vol.; chloroform, 3 vol.; glacial acetic acid, 1 vol.) for half an hour. (2) Dehydrate in absolute alcohol, clear and mount in paraffin block. Sections are cut and mounted on clean slides without albumen. (3) Sections brought rapidly to water and flooded with dialysed iron (B.D.H., 1 vol.; acetic acid (2*M*), 1 vol. for 10 min. (4) Wash well with distilled water. (5) Flood with a solution containing potassium ferrocyanide (0·02 *M*), hydrochloric acid (0·14 *M*), for 10 min. (6) Wash with water and counter-stain with any convenient contrasting dye. (7) Dehydrate rapidly, clear in xylene and mount in Canada balsam.

By treating selected pieces of tissue with a preparation of hyaluronidase from streptococcus prior to stage (2), hyaluronic acid may be distinguished from other blue-staining structures. This hyaluronidase preparation hydrolyses the hyaluronic acid and prevents the combination of the polysaccharide with the iron: the enzyme appears to be specific since it has no similar action on other acid polysaccharides tested. Umbilical cord, muscle and skin have been examined by this method.

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## An Agglutinable Factor in Red Blood Cells

IN 1938, Levine and Katzin[1] described a phenomenon in which the red blood cells of a patient suffering from a severe infection with pneumococcus Type 1 were agglutinated by the sera of about 15 per cent of normal persons. The agglutination occurred at room and lower temperatures but not at 37° C. The authors considered that a latent agglutinogen in the cells was activated by some unidentified mechanism and that this agglutinogen was rendered susceptible to the action of agglutinins which were normally present in the sera. This property of the red cells lasted only for four months. Gaffney and Sachs[2] have described a similar occurrence in two subjects. The first, a boy aged 11 years, had been treated for congenital syphilis for four years. His red cells were agglutinated at room temperature but not at 37° C. Of the sera used the percentage which produced agglutination varied at different times, 89 per cent being the highest. The second was a healthy woman student whose cells were agglutinated at room temperature by 73 per cent of the sera against which they were tested. The 'poly-agglutinability', as the authors term the phenomenon, disappeared in both patients after some months.

A somewhat similar phenomenon has been observed recently with the red cells of a woman whose first pregnancy was terminated at six months because of an increasing hypertension. After delivery, hæmorrhage was severe and one litre of group *O* blood was administered. Three days later she was admitted to hospital with intense jaundice and anæmia (the red cell count was 1,760,000 cells per c.mm.) and died seven days after the fœtus was delivered. Autopsy revealed gross sepsis of the uterus and para-metrial tissue with numerous pyæmic abscesses in the liver. Unfortunately, cultures were not successful due to spreading organisms, but Gram-positive rods were observed both in the uterine tissues and in the liver abscesses. 860 c.c. of group *O* blood were transfused shortly before the patient's death.

It was found that although the patient was group *O*, her cells were strongly agglutinated by all of forty-five sera which were obtained from normal individuals of all groups. The reactions were marked at room temperature (20°–22° C.) and in the ice box (2°–4° C.) but did not occur at 37° C. Repeated saline washing of the red cells and preliminary inactivation of the sera in no way affected the agglutination reaction. It was, however, noted that agglutination of the washed red cells occurred spontaneously when the cells suspended in saline were left overnight in the refrigerator or at room temperature. Unlike the agglutination produced by the sera, this spontaneous agglutination was readily dispersed by agitation. The patient's serum produced no agglutination at room temperature or at 37° C. with numerous suspensions of group *O* red cells from *Rh* positive, *Rh* negative, *M*, *N* and *MN* individuals. Non-specific cold agglutinins and both α- and β-agglutinins were, however, present.

It seems probable, as the other workers have concluded, that some change occurred in the red cells rendering them susceptible to an agglutinin present in normal human sera. The nature of this change could not be determined. Presumably the cells encountered by Levine and Katzin were not as sensitized by the change and thus were agglutinated with only those sera (about 15 per cent) which possessed the agglutinin in highest concentration. The agglutinin to which the cells were sensitized appears to be the non-specific cold agglutinin. The patient's cells after agglutination with normal serum were washed with cold saline and heated to 37° C. The supernatant saline obtained by centrifuging this suspension at 37° C. was found to possess cold agglutinins for normal group *O* cells. Complete absorption of the agglutinin in normal serum could not be effected with the patient's cells because of shortage of the cells. There was, however, some positive correlation between the titre of the cold agglutinins in ten sera tested against normal group *O* cells and the titre of the same sera against the patient's cells.

The abnormal sensitivity of the patient's cells to testing sera could have resulted in an incorrect grouping and transfusion of incompatible blood if the cross-matching test had not been performed.

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## Liebermann–Burchard Reaction

THE Liebermann–Burchard reaction[1] is extensively used for the characterization of polynuclear compounds (steroids, polyterpenoids, etc.). Applying this reaction to some of these compounds and simpler ones, according to the conditions described by Nath, Chakravorty and Chowdhury[2], with enough chloroform to give a homogeneous medium, colloidal solutions are obtained. With cholesterol, β-amyrenol, abietic acid, limonene, cyclohexanone and linalool, the solutions are strongly coloured and show a strong Tyndall effect and Brownian movement by the ultramicroscope.

Adding a large excess of ether (dry over sodium), a precipitate is obtained, which is in each case very soluble in water, affording an acid-base conjugated pair. The colours are shown in the accompanying table.

| Substance | Chloroform solution | Precipitate | Aqueous solution | |
|---|---|---|---|---|
| | | | acid | base |
| β-Amyrenol | pink-violet | blue | violet | yellow |
| Cholesterol | violet-blue-green | green | green | orange |
| Abietic acid | violet-blue-green | grey-green | green | orange |
| Limonene | dark-red | black | brown | yellow |
| Cyclohexanone | dark-yellow-red-dark | violet | violet | yellow |
| Linalool | dark-red | black-brown | green-brown | orange |

The existence of only one acid-base dye was proved chromatographically, passing the aqueous solution through a column with alumina, in acid medium, and in basic medium. The aqueous solutions of the acids and the conjugated base are also colloidal.

When the acids are allowed to stand in contact with the air, they give yellow products soluble in water; the rate of this transformation is greater in presence of light. The yellow products become deeper yellow by addition of bases. Full details will be published at a later date.

We would like to thank Prof. Ruy Couceiro da Costa, director of the Chemical Department, and Prof. A. J. A. de Gouveia, for their interest in this work.

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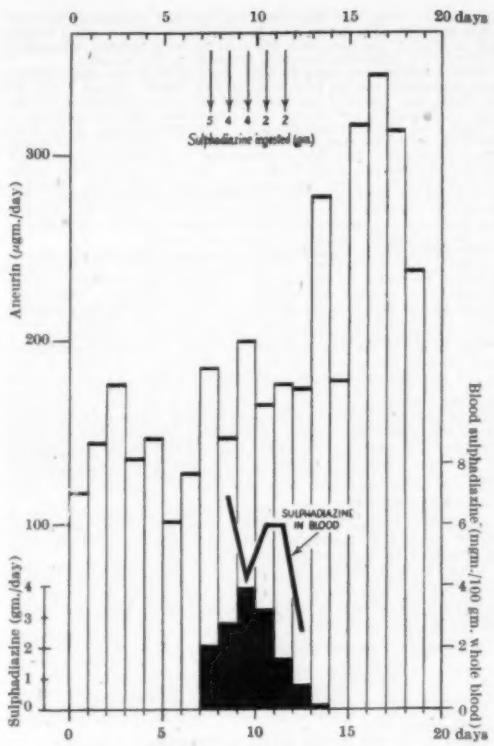
## Effect of Sulphadiazine on the Metabolism of Aneurin in Animals

IT is well established that some of the toxic effects of sulphonamides on animals fed purified diets are caused by inhibition of bacterial synthesis of some B vitamins in the intestine, with consequent development of deficiency states. Few attempts have been made, however, to determine if the sulphonamides have a more fundamental effect on the metabolism of the B vitamins in the animal body. The purpose of the present communication is to make a preliminary report on experiments which suggest that sulphadiazine has an effect on the metabolism of aneurin in the animal body.

A healthy male, aged 27 years and weighing 82·5 kgm., was fed a constant diet for 19 days. The diet provided optimal amounts of all nutrients except aneurin and possibly riboflavin. The aneurin content of the diet was (by analysis) 0·57 mgm. or 0·20 mgm./1,000 Cal. A total of 17 gm. sulphadiazine was given on the eighth–twelfth days; the daily dosage (one quarter of which was taken four times a day) is shown in the graph. Complete daily collections of urine were analysed for aneurin by the thiochrome method. During ingestion of the drug and for a few days afterwards, the total sulphadiazine content of the blood and of the urine was determined by a modification of the method described by Fanti[1]. The results of these analyses are shown in the graph.




EFFECT OF INGESTION OF SULPHADIAZINE ON THE URINARY EXCRETION OF ANEURIN

Open columns: urinary excretion of aneurin; blocked columns: urinary excretion of sulphadiazine; ▬, sulphadiazine content of blood.

The mean daily urinary excretions of aneurin before and during ingestion of sulphadiazine were 136 and 175 μgm. respectively: the increase during ingestion (39 μgm. = 27 per cent) was statistically significant ($P < 0·02$). After ingestion of the drug had ceased, the excretion of aneurin continued to increase, reaching a peak (344 μgm.) five days later, at which time sulphadiazine was no longer detectable in the urine. The aneurin excretion declined over the next few days, but the experiment was discontinued before normal levels of excretion were restored.

Further studies of the effect of sulphadiazine on aneurin metabolism were made by measuring the aneurin content of the liver of rats fed a diet suboptimal in aneurin. The diet was also made suboptimal in riboflavin to enable a study of the effect on riboflavin metabolism. The diet consisted of casein 18 gm., sucrose 73 gm., salt mixture[2] 4 gm., pea-nut oil 2·5 gm., cod liver oil 2 gm., and wheat germ oil 0·35 gm. The following synthetic vitamins were provided per 100 gm. diet: nicotinic acid 5 mgm., pyridoxine 0·5 mgm., inositol 16 mgm., calcium pantothenate 4 mgm. and choline 0·2 gm. In addition, 6·9 μgm. aneurin and 10·3 μgm. riboflavin a day were given by pipette to each rat. Folic acid and biotin deficiency develop in the rat when a sulpha drug is fed with such a diet, owing to inhibition of bacterial synthesis of these vitamins in the intestine. It was therefore necessary to have two control groups, one fed the basal diet

ANALYSES-MEANS OF GROUPS AND SIGNIFICANCE OF DIFFERENCES

| | Means for rats in | | | Significance of difference | | |
|---|---|---|---|---|---|---|
| | Group 1 | Group 2 | Group 3 | Group 1 *v.* Group 2 | Group 2 *v.* Group 3 | Group 1 *v.* Group 2 |
| Overall gain in weight (gm.) | 27·2 | 27·5 | 27·0 | n.s. | n.s. | n.s. |
| Liver weight as % body weight | 3·84 | 4·23 | 3·72 | s. ($P = 0·02$) | h.s. ($P < 0·01$) | n.s. |
| Kidney weight as % body weight | 1·12 | 1·00 | 1·11 | h.s. ($P < 0·01$) | h.s. ($P < 0·01$) | n.s. |
| Total food consumption (gm.) | 199·3 | 190·5 | 194·4 | h.s. ($P < 0·01$) | n.s. | n.s. ($0·05 < P < 0·10$) |
| Aneurin concentration in liver (μgm./gm.) | 3·71 | 5·79 | 3·54 | h.s. ($P < 0·01$) | h.s. ($P < 0·01$) | n.s. |
| Total aneurin in liver (μgm.) | 9·8 | 16·6 | 8·9 | h.s. ($P < 0·001$) | h.s. ($P < 0·001$) | n.s. |
| Riboflavin concentration in liver (μgm./gm.) | 33·1 | 30·0 | 32·2 | n.s. | n.s. | n.s. |
| Total riboflavin in liver (μgm.) | 87·0 | 86·1 | 81·2 | n.s. | n.s. | n.s. |

n.s. = Not significant; s. = significant; h.s. = highly significant; $P$ = probability.

without any drug and the other fed the diet containing succinyl sulphathiazole. The latter drug is absorbed to only a small degree, and therefore it can have little effect on tissues in general, although it is effective in inhibiting bacterial synthesis in the intestine.

Twelve female rats, aged 29 days, were divided into three groups, each containing one rat from each of four litters. Group 1 was fed the basal diet, Group 2 the basal diet with the addition of 0·5 per cent sulphadiazine, and Group 3 the basal diet with the addition of 0·5 per cent succinylsulphathiazole. The growth-rates of all three rats from each litter were kept the same by restricting the food intake where necessary. The food consumption was measured accurately. The weight was practically stationary from the twenty-third to the thirty-second day, when the experiment was terminated. The rats were killed by decapitation and the livers and kidneys weighed. The livers were digested with papain and takadiastase at pH 4·5. Aneurin was determined on the digest by the thiochrome method and riboflavin by the fluorometric method of Slater and Morell[3].

The results of these measurements are summarized in the accompanying table, which gives the statistical significance of the differences between the means for each group. Histological examination of the kidneys failed to show any evidence of kidney damage; this is confirmed by the fact that the kidneys of the rats in Group 2 weighed about 10 per cent less than those of the other rats. Kornberg *et al.*[4] found that kidneys damaged by sulphadiazine were abnormally heavy.

The livers of the rats fed sulphadiazine contained considerably more aneurin but no more riboflavin than those of rats fed no drug or fed succinylsulphathiazole. The concentration of aneurin in the livers of the rats in Group 2 was 64 per cent more than those in Group 3; the total amount of aneurin in the liver was 87 per cent more. There was no significant difference between Groups 1 and 3 in regard to any of the measurements made. This suggests that the effect of sulphadiazine on the aneurin metabolism is not related to the inhibition of bacterial synthesis in the intestine. The efficiency of food utilization of the rats fed the sulphadiazine was slightly but significantly greater than that of the other rats. This may possibly be related to the effect on aneurin metabolism.

An appreciation of the significance of these findings must await the results of further work which is in progress. When this is completed, it and the experiments described in this communication will be presented in detail in another publication.

I wish to acknowledge the assistance of Miss C. E. Francis, who analysed the urines for aneurin in the human experiment; of Mrs. H. M. Schroder and Mrs. D. Gilmour for the analysis of the diet used in this experiment, and of Miss J. E. McNae for the histological examination of the rat kidneys.

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## Frictional Properties of Wool

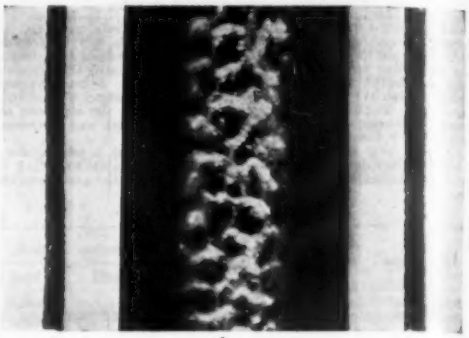
When wool fabrics are rubbed in presence of an aqueous solution of acid or alkali, shrinkage takes place because the fibres migrate in the direction of their root ends. This type of migration is usually referred to the imbricated scale structure of the fibres, but Martin[1] has rejected the ratchet theory and invoked "a particular kind of molecular structure" in the scales of wool to explain its peculiar frictional properties. In order to decide which of these views is correct, fibres were coated with thin films of silver and gold and their frictional properties examined.

The root ends of 80–90 purified Lincoln wool fibres were calibrated by determining their lengths, diameters and weights at 65 per cent relative humidity and 22·2° C. The fibres were then mounted in parallel across a light steel grid and exposed in high vacuum to the vapour from molten silver or gold[2]. To ensure uniform coating of the fibres, several brief exposures were given with the grid rotated into different positions by means of a magnet. Although the exposed fibres were completely coated with metal, their scale structure was well defined, as may be seen from the accompanying photomicrographs.

The thickness of the metal film was calculated in each case from the gain in weight of selected fibres during exposure, and confirmed by determining the loss in weight when the metal film was removed. Scaliness measurements were made on the remaining fibres by two methods[3–5]. The results are given in the accompanying table.

Although less than that of untreated fibres, the scaliness of fibres coated with the thinner film of silver (0·03 $\mu$) is remarkably well defined. In addition, the fibres were found to creep on being rubbed between moistened glass plates. Since the metal film was intact after each of these determinations, it must be concluded that the peculiar frictional properties of wool are due to the ratchet effect of the scales.

| Nature of fibre | Thickness of film ($\mu$) | Scaliness | |
|---|---|---|---|
| | | Violin bow method (%) | Lepidometer (gm.) |
| Untreated | — | 38·8 | 2·90 |
| Silver-coated | 0·030 | 25·2 | 1·77 |
| Untreated | — | 39·2 | — |
| Silver-coated | 0·056 | 5·3 | — |
| Untreated | — | 39·2 | — |
| Gold-coated | 0·052 | 6·0 | — |



(*a*) Silver-coated fibre (× 100), diffuse light
(*b*) „ „ (× 250), reflected „
(*c*) Gold-coated „ (× 100), diffuse „

With thicker films of silver or gold, the differential frictional effect, as measured by the violin bow method, is almost entirely eliminated, although scales were clearly visible under the microscope. Lepidometer measurements were unreliable, owing to removal of metal, but creep between glass plates was found to be impossible. It seems probable, therefore, that the thicker film of metal increases the rigidity of the scales, or seals the small gap[5] between the scale edges and the body of the fibre, thus making unidirectional movement according to the Rudall model[6] impossible.

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## A Bent Pebble

Another explanation may be offered of the origin of the 'bent pebble' described by Dr. J. S. Lee[1]. It may represent a worn-out fragment of silicified sandstone adjoining a right-angle joint junction in the rock. In many places along the Yorkshire coast and elsewhere I have seen somewhat similar angular pebbles obviously derived from septaria-skeletons ('melikaria'). These septaria-skeletons represent quartzose infillings of the cracks of the septarian nodules, and they are set free by the weathering of the surrounding nodule material. Joints in sandstone are often rimmed by zones of silicified rock which is usually much harder than the original sandstone. On weathering, the softer rock inside the joint blocks is removed first, with the result that the silicified rims are set free. A fragment taken from a knee portion of such a rim could easily have been detached and abraded into a shape resembling the 'bent pebble'. In this case the bending of the pebble would represent an original feature of the rock and would not be due to any subsequent tectonic deformation.

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[1] *Nature*, **157**, 590 (1946).

## Mechanism of Colour Discrimination and a New Type of Colour Blindness

In a previous letter[1], it was suggested that differences in the luminosity curves are caused by varying numbers of receptors. In order to find new evidence for this, it seemed worth while to study the intensity discrimination and the visual acuity of the three sets of receptors, as these functions depend upon the number of elements. The blue apparatus was studied first. Two methods were used:

(*a*) The first method has been described already[2]. A constant small blue spot $P$ was projected on a large field $F$, which could be illuminated by the same blue light $B$ ($\lambda = 455$ m$\mu$) and by green light $G$. First the intensity of $B$ was adjusted to $B_1$, by the observer so that $P$ vanished. Then an appropriate amount of $G$ was added so that the blue apparatus alone could detect $P$. The new value $B_2$ was distinctly smaller than $B_1$. $B_2/B_1$ gives the ratio of the intensity discrimination of the blue apparatus compared to the red and green apparatus. For five observers we found the values 2·3, 4·1, 2·3, 3·0, 2·8.

A special series of measurements was carried out to prove that the three mechanisms were acting independently of each other. In the

| | *a* | *b* | *c* | *d* | *e* | *f* | *g* | *h* | *i* |
|---|---|---|---|---|---|---|---|---|---|
| Amount of blue | 0 | 33° | 33° | 31° | 42° | 60 | 64° | 120° | 270° |
| Total excitation of green | >4000 | 94 | 49 | 41 | 35·5 | 35 | 34 | 35 | 35 |
| Amount of green | >4000° | 90 | 45 | 37 | 30 | 27° | 25 | 20 | 0 |

accompanying table in each column the combinations of green and blue are given which make a spot *P* vanish (wave-length 480 mμ).

The amounts marked with an asterisk have been adjusted by the observer. As the blue field excites the green receptors also, the amounts of green have been corrected for this excitation (row 2). The sudden increase of the excitation of green from *e* to *d*, and the increase of the amount of blue from *d* to *e*, etc., shows that the interaction between the different mechanisms is small.

The visual acuity of the blue receptors is very small; on a green field *P* is seen as a blue gloom without a definite shape.

(*b*) The same results were found by a second method. Here two semicircular fields of the colour-mixing apparatus were used; the limits were determined where a difference between the upper and lower field became visible. Blue light, green light and mixtures of blue and green were used on both fields; only one of the components was varied.

These experiments are equivalent to measurements of wave-length discrimination, and hence wave-length discrimination can be explained by the theory used above, namely, that the eye includes three separate mechanisms, each having its own intensity discrimination and visual acuity.

Analogous measurements were carried out on the green mechanism. A green spot was used ($\lambda = 550$ mμ). The large field was illuminated by green and/or red light. No definite results were obtained for three observers, *G*, *P* and *L*, but we are sure that the intensity discrimination of the green mechanism is nearly as good as for the red mechanism. According to the measurements already reported[1], *G* had an exceptionally large number of green receptors; indeed his discrimination of *P* on a red field was 20 per cent better than for *P* or *L*. The green mechanism of *B*, however, showed a reduction of the discrimination by a factor of two. Indeed, she had a very low number of green receptors since her luminosity curve was only 4 per cent above my own curve (see ref. 1). Her reading of Stilling's test cards was somewhat reduced. In the Rayleigh test she required an amount of red that was *Q* times as large as the amount used by a 'normal' observer; *Q* being 1·1. This is no reason, however, for calling her a protanomalous, especially since her luminosity curve is very low. Moreover, for *G*, *Q* was 1·15, but *G* read the test cards very well.

The luminosity curve of *D* (trichromat) coincided with mine; indeed he read the test cards very badly; even worse than *K* (deuteranomalous). The coefficient *Q* for *D* and *K* was 0·9 and 0·3 respectively, but *K*'s luminosity curve was 10 per cent higher than mine and therefore he had more green receptors and a better colour discrimination.

We finally conclude that a flicker photometer may be a valuable instrument in the detection of colour blindness (but combined with the anomaloscope), especially because the colour-blind can adjust the minimum of flicker very accurately. Settings which suggest unusual sensitiveness or insensitiveness to red point to a colour-discrimination.

These measurements will be reported in more detail elsewhere. Our thanks are due to Prof. G. F. Rochat for his help and advice in the clinical tests.

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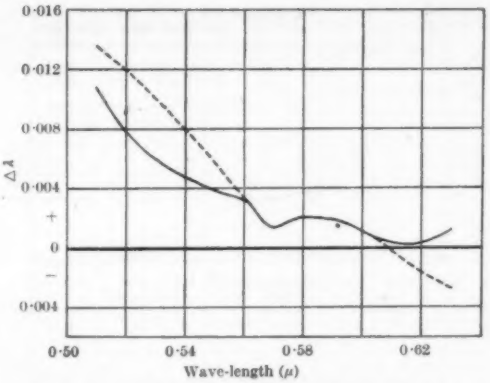
## Foveal Colour Sensitivity

RECENTLY, during the measurement of the hue discrimination curves for small areas of the retina within the central fovea, it was noticed that if the two halves of the small circular matching field (diameter subtending 15′ at the eye) were set at the same wave-length $\lambda$, the lower beam, which did not quite match the upper beam in colour, had to be displaced slightly to a new wave-length $\lambda \pm \Delta\lambda$ if a perfect colour match was to be obtained.

These differences ($\Delta\lambda$) for various wave-lengths are shown in the accompanying graph. The full curve was obtained when the matching field was viewed directly so that its image lay upon the retina at the fixation point; whereas the broken curve was found when the field was displaced 20′ into the left visual field by the use of a small fixation light. Between 0·560 μ and 0·600 μ the curves appear to be the same, and throughout most of the spectrum investigated when both fields were set to the same wave-length, the lower field appeared slightly more blue than the upper one. Beyond 0·510 μ and 0·630 μ hue discrimination becomes so poor that $\Delta\lambda$ cannot be measured with precision. A further point of interest is the notch in the curve at 0·570 μ.

The measurements were made with the colorimeter developed by Dr. W. D. Wright[1-3]. The right eye was used and the field brightness was approximately 50 photons. A careful check of the wave-length calibration of the colorimeter was undertaken, and to make certain that the effect was not due to an error within the apparatus a small reversing prism was fitted to the eyepiece so that the position of the upper and lower beams was reversed. Since the lower field (now illuminated by the upper beam) still remained slightly more blue than the upper one, the effect could scarcely be due to faulty wave-length calibration.




The size of $\Delta\lambda$ (see graph) for any wave-length is only about half that of the hue discrimination step for the same wave-length under the same conditions, and $\Delta\lambda$ is merely the difference of wave-length which makes a colour match unsatisfactory, and is not sufficient for one to be able to record a reproducible hue step. The need for some adjustment of the wave-length control of the colorimeter, however, was readily seen by the observer.

Thomson and Wright[3] have shown that there is an increase of sensitivity to blue light as the image of the matching field is moved from the centre towards the edge of the central fovea, and the explanation of the colour difference here described may be that the fixation point was such that the two halves of the field lay upon areas of the retina of slightly different spectral sensitivity. The irregular shape of the curve may be due to the image of the matching field having a retinal position which depends upon the wave-length. Some difference in the anatomical position of the fixation point for red, green and blue light has been reported by Hartridge[4], and it may be that the position of the fixation point is a continuous function of the wave-length when small matching fields are used.

I would like to express my thanks to Dr. W. D. Wright for his help and to Miss M. Gilbert for recording the observations. My thanks are also due to the Medical Research Council for the use of the colorimeter at Imperial College.

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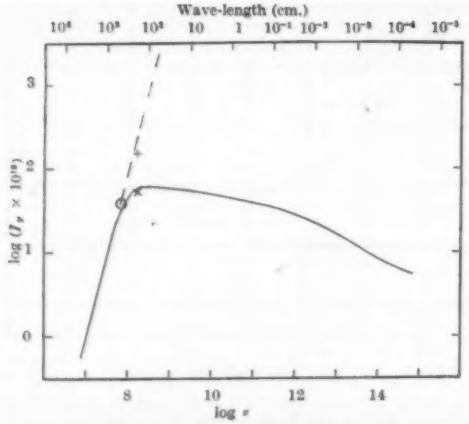
## Interstellar Origin of Cosmic Radiation at Radio-Frequencies

RECENT publications of measurements of radiation from interstellar space[1] and from the sun[2-3] have important astronomical consequences. In the measurement of cosmic radiations at 5 metres wave-length, the maximum value of $13{\cdot}2 \times 10^{-21}$ $\Delta\nu\Delta\omega$ watts/sq. metre was obtained. This is equivalent to a radiation intensity of $4 \times 10^{-18}$ ergs/sec./kilocycle band-width/sq. cm./sq. degree. We have previously investigated[4] the theory of interstellar radiation arising from free-free transitions by electrons in the field of protons. From astronomical observations the numbers of protons and electrons in interstellar space, in the neighbourhood of the sun, are known to be of the order of 1 per cubic centimetre. On this basis we computed the expected intensity of radiation at the earth; the maximum predicted value is found to be $5 \times 10^{-18}$ ergs/sec./kc./sq. cm./sq. degree, at about 1 metre wave-length. The accompanying graph shows the predicted free-free radiation from interstellar space as well as the presently available high-frequency measures. The plotted observations are the observed maximum intensities, in the region of Sagittarius. Data at the slightly longer wave-length bands, near 10 metres, would be of critical importance. The new and accurate observations by Hey, Phillips, and Parsons[1] lie remarkably close to our predicted curve. Their observations show relatively low concentration of the radio-frequency radiation to the galactic plane, compared to both interstellar matter and stars. Possibly a slight under-estimation of background noise might explain this effect.

Hey[1], working at 5 metres, and Pawsey, Payne-Scott and McCready[3] at 1·5 metres, have observed intense short-wave bursts of radiation from the sun, connected with sunspot activity. The energies received attain high values; their data are given in terms of an 'equivalent temperature'. After reduction to our units, the observed intensities are respectively of the order of $5 \times 10^{-13}$ and $3 \times 10^{-14}$ ergs/sec./kc./sq. cm./sq. degree. Pawsey, Payne-Scott and McCready[3] question the origin of the cosmic radiation in interstellar space, and "attribute it to similar [that is, to the sun] bursts of radiation from the stars, which, because of their large number, could yield an approximately constant value for any one area in the sky". We wish to point out some considerations which seem to vitiate this interesting new suggestion. In




THE FULL CURVE REPRESENTS THE COMPUTED RADIATION FROM FREE ELECTRONS IN INTERSTELLAR SPACE, IN THE DIRECTION OF SAGITTARIUS. THE BROKEN LINE SHOWS BLACK-BODY RADIATION FROM A TEMPERATURE OF 10,000°. OBSERVATIONS: BY HEY, PHILLIPS AND PARSONS ARE SHOWN BY THE OPEN CIRCLE; BY REBER AS CROSSES:—1940 (×) AND 1944 (+)

the first place, it is necessary to consider the fraction of the area of the sky covered by stellar disks (the 'dilution' of stellar radiation). This fraction depends on the space density of the stars, on stellar radii, and on the extent of the galactic system. Numerical data are given by Dunham[5] for stars of various types. Stars similar to the sun, dwarf *F*0 to *M*, and giant *F*0 to *G*9 all have similar dilutions, $\delta = 10^{-14}$. It may be thought that hotter stars would be more efficient because of their higher luminosities. However, because of the relatively small number of such stars in space, $\delta$ drops to $10^{-17}$ for *B*0 stars.

The energy received at the earth from the cooler stars, assuming a constant emission at the maximum level observed by Hey[2], would be $5 \times 10^{-27}$ ergs/sq. cm./sec./kc./sq. degree, which is of the order of $10^{-9}$ of the observed cosmic radiation. The solar observations indicate that the time-average radiation is considerably lower than the peak value, on which the above figure is based. A low time-average would lead, of course, to an even greater discrepancy. If the hotter stars are considered, the larger dilution results in a discrepancy of $10^{-12}$, without considering the time-average effect. In other words, a hot star would have to suffer disturbances $10^{12}$ times as intense as those observed in the sun, per unit area of its disk, if such bursts are to account for the cosmic radiation at radio frequencies. It would seem probable that the solar observations represent a new and different type of phenomenon from that observed by Reber[6] and by Hey, Phillips and Parsons[1].

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[1] Hey, Phillips and Parsons, *Nature*, **157**, 297 (1946).
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## Separation of Nuclear Isomers in the Electric Field

Segré, Halford and Seaborg[1] demonstrated the isomeric filiation of bromine 80 by a chemical method on the basis of the Szilard–Chalmers process. We have carried out experiments in which the isomeric filiation is proved by a physical method, collecting the isomers when partly separated by means of an electric field using electrodes in a non-electrolytic solution.

To study the isomeric filiation of bromine 80 of two periods, 17·4 min. and 4·4 hr., 250 c.c. of $C_2H_4Br_2$, surrounded by water, were irradiated for 15 hours by means of neutrons of a radium-beryllium source of 400 mC. After irradiation, the solution was submitted to an electric field (115 volts/cm.) for three hours. The electrodes used are silver plates of 5 cm. × 4 cm., 3 cm. apart.

Three hours after irradiation, all the bromine of 17·4 min. period directly formed has gone, and the 17·4 min. period activity collected on the plates is produced by isomeric filiation (Fig. 1). The same experiment has been made without field (Fig. 2). In both cases the activities of the anode were measured by a Geiger–Müller counter, using a scale of sixteen. With the electric field (Fig. 1), the 17·4 min. period appears very strongly.

In such experiments, the question of the expulsion of bromine from the molecule does not seem to be concerned as is the case in chemical separation, where the recoil effect is the important factor[1–4]. Here the effect seems to be based mainly on the ionization.

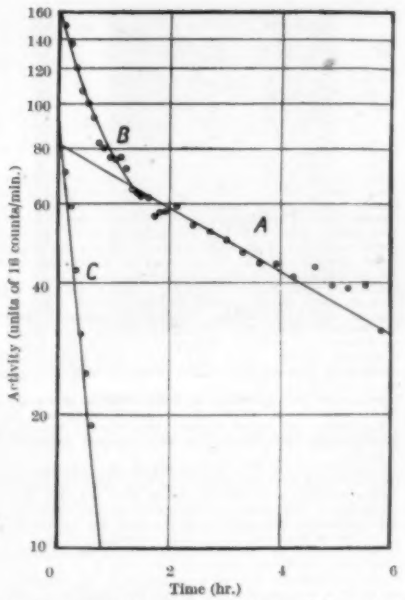


Fig. 1. WITH ELECTRIC FIELD. *A*, BROMINE, 4·4 HR. ACTIVITY; *B*, BROMINE, 17·4 MIN., AND 4·4 HR. ACTIVITIES; *C*, BROMINE, 17·4 MIN. ACTIVITY

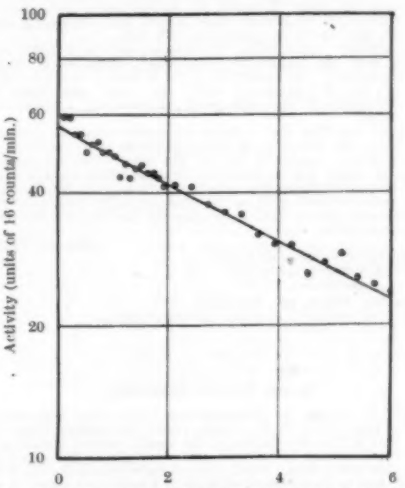


Fig. 2. WITHOUT ELECTRIC FIELD. BROMINE, 4·4 HR. ACTIVITY

By this method we hope to be able to determine the conversion factor[5]. We also hope to apply the method where the chemical separation has failed and as far as conversion permits.

In the case of $C_2H_4Br_2$, more activity was collected on the cathode than on the anode. A first experiment with $C_2B_5Br$ shows more activity on the anode, as in the results of Fay and Paneth[6].

A full report will be published later.

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## Statistical Analysis of Spontaneous Electrical Fluctuations

THE mechanical Brownian movement of various systems has been very thoroughly investigated in the past, and corresponding detailed statistical analyses of the experimental records have been carried out in order to check the fundamental assumptions of the theory. Of particular interest is an investigation by E. Kappler[1] on the Brownian movement of a torsion balance, using amplification by a beam of light to obtain direct photographic records. Experimental work on the analogous phenomenon in electrical circuits which, in certain limiting cases, manifests itself either as 'thermal fluctuation of current'

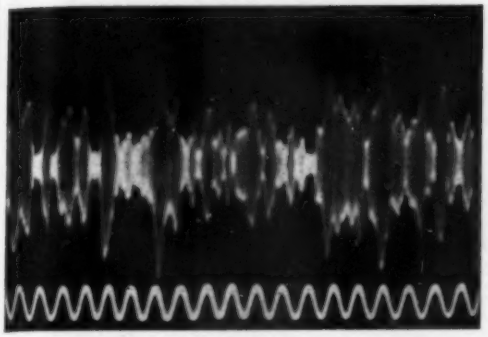

Fig. 1. CATHODE RAY OSCILLOGRAM OF ELECTRICAL FLUCTUATIONS IN A CIRCUIT OF NATURAL FREQUENCY 1 MC./S., WITH A BAND-WIDTH OF ONE OR TWO KILOCYCLES/SEC. THE WAVE AT THE BOTTOM OF THE FIGURE IS A HARMONIC OSCILLATION OF 1 KC./S. USED AS TIMING SIGNAL

or as 'shot effect' (in the jargon of electrical engineering usually referred to as 'noise') has, however, in the main been confined to observations of the magnitude of the fluctuations. A complete statistical theory, based on earlier work by Ornstein[2], Uhlenbeck[3], and others, was recently developed by S. O. Rice[4], on the assumption that the fluctuations of current in a circuit originate from completely uncorrelated random events. He derived expressions for the distribution of the variations of current in time in terms of the electrical characteristics of the circuit; from which, in particular, the magnitude of the

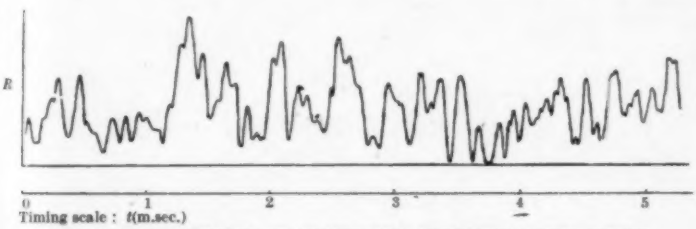


Fig. 2. TRACED ENVELOPE OF AN ELECTRICAL FLUCTUATION RECORD SHOWING THE VARIATION OF AMPLITUDE $R$ IN TIME $t$

fluctuations and their correlation over a finite time-interval can be obtained. We therefore considered it to be worth while to produce records of electrical fluctuations under different conditions in order to compare them with the theory and to find out whether the underlying general principles of the theory were justified.

The records were obtained photographically from traces of the highly amplified fluctuations on the screen of a cathode ray oscillograph, and the band-width and frequency of the 'receiver' were suitably chosen so as to provide freedom from alien disturbances such as the 'flicker effect'[5]. Fig. 1 is a typical example of such a record, showing that the fluctuations have the character of very rapid oscillations with irregularly varying amplitude, similar to the results of the above-mentioned experiments on the Brownian motion of a torsion balance with very low air pressure. As these amplitude fluctuations are the only interesting feature of the phenomenon, an 'envelope' of the current record was traced with the help of an enlarger, which shows the variations of amplitude $R$ in time (Fig. 2). These curves were submitted to a detailed statistical analysis, and in particular the distribution function of $R$ and its correlation over various time intervals was obtained. The agreement with the theory proved to be very satisfactory.

It was also attempted to find out whether fluctuations 'generated' primarily in a saturated diode or in a tuned circuit with high dynamic impedance would produce differences in the statistical character of the records. An indication which is just possibly significant of a difference in correlation has been observed in the records, which might arise from a degree of interaction between the 'primary events' in the latter case.

A detailed account of this investigation will be published elsewhere. It is hoped that further work on this subject can be undertaken in the future.

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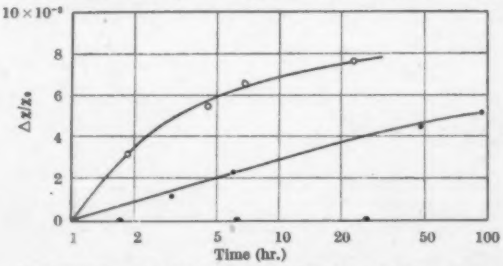
## Magnetic Self-Recovery in Cold-Worked Copper

FROM time to time many investigations have been carried out on the effect of cold-working on the magnetic properties of various metals[1], but there are still no very reliable conclusions to be drawn from the work. We have recently been making a comprehensive study of the effect of cold-working on the magnetic properties of pure metals, over a range of temperatures, and in the case of copper have observed evidence of a systematic change of magnetic susceptibility with time. This effect is most easily interpreted as a magnetic self-recovery or self-annealing of the metal, the observed susceptibility gradually approaching a stable value at a rate dependent on the temperature at which the metal is maintained. This effect appears to be related to X-ray observations which have recently shown that a self-recovery of cold-worked copper takes place fairly rapidly, even at room temperature[2,3,4].

The metal used in our experiments was very pure 'H.S.' brand copper supplied by Johnson, Matthey and Co., Ltd., in the form of rods 5 mm. in diameter and 15 cm. long. Cold-working was carried out by drawing the previously annealed rods through hardened steel dies, and magnetic susceptibilities measured by the Gouy method using an electrodynamic balance which we have described elsewhere[5]. After drawing, the specimen was brought to the desired temperature and susceptibility measurements commenced in each case approximately one hour after drawing. Thereafter the specimen was maintained at constant temperature and its susceptibility observed at intervals extending, in the measurements made at room temperature, over a total time of about 100 hours.

The accompanying graph shows the fractional change in the observed susceptibility as a function of time, for cold-worked specimens maintained at three different temperatures. We have here plotted $\Delta\chi/\chi_0$ on a logarithmic time-scale; $\chi_0$ indicates the value of the susceptibility measured with the specimen at the indicated temperature, at approximately one hour after cold-working in each case. Taking first the measurements made at room temperature, it will be seen that the susceptibility changed by 5 per cent in approximately 100 hours and was still changing after that interval, though at a somewhat slower rate. With the cold-worked copper maintained at 90° C. a change of nearly 8 per cent occurred in 25 hours, a stable state apparently being very nearly reached after that time. With the copper maintained at − 180° C. no change of susceptibility outside the limits of accuracy of the measurements could be detected over an interval of 25 hours. (The *relative* accuracy of the individual measurements on each curve is about 0·25–0·5 per cent.)

It might be noted that these cold-worked specimens, after annealing in hydrogen at 900° C. for 2 hours, all gave closely similar values for the susceptibility, namely, $-0{\cdot}085_5 \times 10^{-6}$ C.G.S. units per gm., without any evidence of ferromagnetic impurity. The 'cold-worked susceptibilities' actually measured one hour after drawing, namely, $\chi_0$, were − 0·066, − 0·078 and − 0·079 × $10^{-6}$ respectively at temperatures of 90° C., 5° C. and − 180° C. The degree of cold-working, as measured by the reduction in cross-sectional area of the rod, was 35 per cent in the case of the specimen measured at 5° C. and 20 per cent in the two other specimens. It will be seen that although cold-working does reduce (numerically) the measured susceptibility, there is no evidence in the present experiments of cold-worked copper




VARIATION OF MAGNETIC SUSCEPTIBILITY OF COLD-WORKED COPPER WITH TIME
Open circles, at 90° C.; filled circles, at 5° C.; points on time axis, at − 180° C.

becoming paramagnetic, as has been occasionally reported[1]. There is, however, an appreciable temperature variation of susceptibility of the cold-worked specimen, which appears to differ somewhat from that of the annealed metal; this is being investigated separately.

The simplest interpretation of the present results would appear to be that the magnetic susceptibility is strain-sensitive. Self-recovery takes place, slowly at room temperatures and more rapidly as the temperature is raised, although at sufficiently low temperatures the self-recovery appears to be arrested. Kussmann and Seemann[5] have attempted to show that the apparent change of magnetic susceptibility with cold-working in non-ferrous metals is really due to the presence of minute amounts of ferromagnetic impurity in the metals. The X-ray evidence of self-recovery, in the form of decrease in line-broadening[2] and the appearance of distinct spots in the lines[3], coupled with the fact that the magnetic susceptibility itself shows a self-recovery, appears to support the idea that susceptibility is in fact strain-sensitive. The theoretical implications of this conclusion are of obvious importance, and more extensive magnetic investigations may be expected to throw additional light on the nature of cold-work and internal strain in metals.

Details of further work will be published elsewhere.

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## Barium Titanate: a New Ferro-Electric

I HAVE earlier discussed the high permittivity of barium titanate and its temperature behaviour[1]. Additional experimental results such as the dependence of permittivity on the electrical field strength, the dielectric hysteresis loops and the maximum in the thermal capacity at the permittivity peak temperature show that this substance is a new type of ferro-electric. It should be noted that, as distinct from other known ferro-electrics, barium titanate does not contain hydrogen. For practical purposes, it is important to note that it may be used as an electrical insulator in which the ferro-electric properties are manifest over a wide temperature range. A detailed article will be published in the *Journal of Physics*.

Prof. W. Jackson and W. Reddish[2] have recently announced that the peak permittivity-temperature behaviour observed in barium titanate is also characteristic of the solid solution of $BaTiO_3-SrTiO_3$. It seems very probable that solid solutions of $BaTiO_3-SrTiO_3$ are ferro-electrics, as it is known[3] that mixed isomorphous crystals of Rochelle salt $NaKC_4H_4O_6.4H_2O$ and $NaNH_4C_4H_4O_6.4H_2O$ are ferro-electrics.

In my former communication[1], I mentioned the experimental result that the dielectric constant of titanates of perovskite structure were found to grow with an increase in the size of the alkaline-earth ion. It was clear that this referred to pure materials, and should not be extended to the permittivity-temperature behaviour of a mixed ferro-electric substance near the Curie point.

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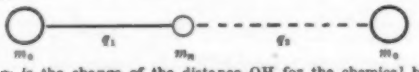
## Interpretation of the Regularities in the Spectra of Molecules Forming the Intermolecular Hydrogen Bond by the Predissociation Effect

A most effective method of investigation of the hydrogen bond is the study of changes in vibrational spectra when the molecules are forming complexes. The results may be easily explained with the help of the predissociation theory and the Frank–Condon principle both applied to the energy-levels and transitions between them in the system:




where $q_1$ is the change of the distance OH for the chemical bond, $q_2$ is the change of distance between the oxygen and the hydrogen atoms for the hydrogen bond. The energy operator for such a system has the form

$$H(q_1) + H(q_2) + H(q_1 q_2).$$

Omitting $H(q_1 q_2)$, we obtain as a solution of the corresponding Schrödinger equation a system of levels of the molecule OH and a system of levels for the hydrogen bond. The magnitude of the fundamental vibrational quantum of the molecule OH is 3,650 cm.$^{-1}$. The magnitude of the quanta of the system H . . . O is very small; they are quickly converging to the dissociation limit (3,000 cm.$^{-1}$). If the influence of the operator $H(q_1 q_2)$ is taken into account, the interaction of the level $V=1$ for the group OH with the set of continuous levels of the group H . . . O, lying higher than the dissociation limit, leads to the broadening of the level and to the disappearance of the discrete structure that is observed in the spectrum.

The breadth of the band and its shift in the frequency scale compared with a line of the gas (3,650–3,400 cm.$^{-1}$) is explained in the following way. In absorption the most probable transitions are those for which the positions of the heavy oxygen atoms change least. As the average distance between the oxygen and the hydrogen atoms for the transition $V=0 \rightarrow V=1$ increases due to the anharmonicity of the OH bond, the distance between the atoms of oxygen and hydrogen forming the hydrogen bond decreases, the decrease being of the same magnitude $dq$. To this change $dq$ in the set of energy-levels of the hydrogen bond correspond only those transitions for which the energy of the system decreases.

These conceptions also make it possible to explain the dependence of the shift and of the band-breadth on temperature, the behaviour of the solutions of molecules connected one with another by a hydrogen bond, the properties of the spectra of molecules connected by a deuterium atom, and the properties of overtones of the frequencies 3650.

A detailed account of this investigation will be published in the *Journal of Physical Chemistry* (U.S.S.R.).

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## Quantization of the Solar System

CONSIDERATIONS having no bearing on the present subject lead to the conclusion that the spin of elementary particles can be computed if the gravitational constant and the velocity of light are known; and further that the protonic spin is slightly greater than the electronic spin. Should these considerations prove correct, the two conditions mentioned suggest that the Planck constant has not the meaning of a universal physical constant, and that its numerical value is always dependent on the value of the spin of the elementary particle taking part in the physical phenomenon in question. Accordingly, to mention only a simple example, in the case of Bohr's atom model, the principal quantum number does not correspond to the equation

$$n = \frac{\text{orbital impulse}}{\hbar}; \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

but to

$$n = \frac{\text{orbital impulse}}{2 \times \text{electronic spin}} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The question arises whether equation (2) is not applicable to the orbits of the planets in the modified form:

$$n = \frac{\text{orbital impulse}}{2 \times \text{planetary spin}} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Quantization of the orbits has not yet been thought of as equation (1) leads to extremely high numbers. The quantum numbers obtained with the aid of equation (3) are still very high. On closer examination, however, it becomes evident that the quantum numbers thus obtained are 1, 2, 3, 4 . . . times the integral powers of Sommerfeld's fine structure constant; divided by this factor, the orbits of the planets can be quantized on the basis of the equation:

$$n = \frac{\text{orbital impulse}}{2 \times \text{planetary spin}} \cdot 137^{-k} \quad . \quad . \quad (4)$$

| Planet | $n$ | $k$ | Time of revolution |
|---|---|---|---|
| Venus | $0{\cdot}97 \simeq 1$ | 3 | (24)* hours |
| Earth | $1{\cdot}04 \sim 1$ | 3 | 24 ,, |
| (Vulcanus) | 2 | 3 | (24) ,, |
| Pluto | $3{\cdot}04 \sim 3$ | 3 | (11·7) ,, |
| Mercury | $4{\cdot}00 \sim 4$ | 3 | (24) ,, |
| Mars | $5{\cdot}15 \sim 5$ | 3 | 24·6 ,, |
| Jupiter | $1{\cdot}06 \sim 1$ | 2 | 9·9 ,, |
| Saturn | $2{\cdot}10 \sim 2$ | 2 | 10·2 ,, |
| Uranus | $1{\cdot}87 \sim 2$ | 2 | 10·8* ,, |
| Neptune | $3{\cdot}01 \sim 3$ | 2 | 15·8 ,, |

It is assumed that inside the planets the distribution of the density is identical with the distribution of density of the earth[2] (moment of inertia $T = 0{\cdot}28\ MR^2$). In the case of Pluto the time of revolution was taken to be identical with the average value of the time of the revolution of the other outer planets, and further that its density does not exceed that of the earth.

It seems as if Pauli's rule would be valid even for planets, that is, that the values of $k$ and $n$ cannot be the same for any two planets, except if they revolve in opposite senses as is the case for Saturn and Uranus; but then we must infer that the revolution of Venus must be also retrograde.

According to the table, a planet with $k = 3$ and $n = 2$ does not seem to exist; it is possible that the innermost hypothetical planet Vulcanus, situated between the sun and Mercury—the existence of which is suggested by the anomalies in the orbital motion of Mercury—should fulfil these conditions. Taking its distance from the sun as $30 \times 10^6$ km., we get, according to equation (4), about 6,000 km. for its diameter.

It must be stressed that the role of the factor 137, the occurrence of which elsewhere in physics is inexplicable, is also here incapable of explanation. Nevertheless, the results enable one to estimate the time of revolution for the planets Venus, Mercury and Pluto, which are as yet incomputable by astronomical observations. Besides Kepler's law, reduced by Newton to general laws, and the Bode–Titus rule, computed theoretically by Weizsäcker[2], the above quantization may serve as a third correlation for the definition of the elements of planetary motions.

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## Relative Nature of Electromagnetic Radiation

By using the method of instantaneous infinitesimal Lorentz transformation, we obtain transformation coefficients connecting the two systems $S'$ and $S$, with $S'$ at rest and $S$ in accelerated motion. Here we give these coefficients for the simplest case, on putting the velocity of $S$ equal to zero after differentiation:

$$\frac{\partial x'}{\partial x} = 1 - \frac{x'\Gamma}{c^2}, \quad \frac{\partial x'}{\partial y} = -\frac{y'\Gamma}{c^2}, \quad \frac{\partial x'}{\partial z} = -\frac{z'\Gamma}{c^2}, \quad \frac{\partial x'}{\partial t} = \frac{r'\Gamma}{c};$$

$$\frac{\partial y'}{\partial x} = 0, \quad \frac{\partial y'}{\partial y} = 1, \quad \frac{\partial y'}{\partial z} = 0, \quad \frac{\partial y'}{\partial t} = 0;$$

$$\frac{\partial z'}{\partial x} = 0, \quad \frac{\partial z'}{\partial y} = 0, \quad \frac{\partial z'}{\partial z} = 1, \quad \frac{\partial z'}{\partial t} = 0;$$

$$\frac{\partial t'}{\partial x} = -\frac{x'^2\Gamma}{c^2r'}, \quad \frac{\partial t'}{\partial y} = -\frac{x'y'\Gamma}{c^2r'}, \quad \frac{\partial t'}{\partial z} = -\frac{x'z'\Gamma}{c^2r'}, \quad \frac{\partial t'}{\partial t} = 1 + \frac{x'\Gamma}{c^2};$$

where $x', y', z', t'$ and $x, y, z, t$ are the co-ordinates of a point relative to $S'$ and $S$ respectively. The values are taken at the time $t' = r'/c$, and $\Gamma$ is the instantaneous acceleration of $S$ along the $x$-direction. We apply these coefficients to the special case of a charged particle placed at the origin of $S$, the accelerated system. The electromagnetic field, a six-vector, will be transformed according to

$$F^{\mu\nu'} = \frac{\partial x'_\mu}{\partial x_\alpha}\frac{\partial x'_\mu}{\partial x_\beta}F^{\alpha\beta}. \quad . \quad . \quad (2)$$

Let the field of the charge in $S$ be Coulombian, that is,

$$\vec{E} = \frac{\vec{er}}{r^3}, \quad \vec{H} = 0.$$

Then the field observed by $S'$ will be given, by substitution of the coefficients (1) in the equation (2), by

$$E_x' = \frac{ex}{r'^3} - \frac{e\Gamma}{c^2r'} + \frac{e\Gamma_{r'}x}{c^2r'^2}, \qquad E_y' = \frac{ey}{r'^3} \pm \frac{e\Gamma_{r'}y}{c^2r'^2},$$

$$E_z' = \frac{ez}{r'^3} + \frac{e\Gamma_{r'}z}{c^2r'^2};$$

$$H_x' = 0, \qquad H_y' = -\frac{e\Gamma z'}{c^2r'^2}, \qquad H_z' = \frac{e\Gamma y'}{c^2r'^2};$$

$$\text{where } \Gamma_{r'} = \Gamma\frac{x'}{r'}. \quad (3)$$

These are identical with the field obtained by solving Maxwell's equations. The field of a charge with arbitrary velocity $\vec{v}$ and acceleration $\vec{\Gamma}$ is obtained by further applying a finite Lorentz transformation to the above result (3) and is

$$\vec{E'} = \frac{e(1-\beta^2)o_1\vec{p}}{r'^3(1-\beta_{r'})^3} + \frac{e\Gamma_{r'}o_1\vec{p}}{c^2r'^2(1-\beta_{r'})^3} - \frac{e\vec{\Gamma}}{c^2r'(1-\beta_{r'})^2};$$

$$\vec{H'} = \frac{e(1-\beta^2)[\vec{v}\vec{r'}]}{cr'^3(1-\beta_{r'})^3} + \frac{e\Gamma_{r'}[\vec{v}\vec{r'}]}{c^2r'^2(1-\beta_{r'})^3} + \frac{e[\vec{\Gamma}\vec{r'}]}{c^2r'^2(1-\beta_{r'})^2}; \quad (4)$$

where $\vec{o_1p} = \vec{r'} - \vec{v}\frac{r'}{c}$, etc.,

in complete agreement with the usual classical theory. Therefore the field due to an accelerated charge can be obtained from a Coulomb rest field by applying the infinitesimal Lorentz transformation (1) and a finite Lorentz transformation.

Next, we wish to find the field due to a charge at rest observed by an accelerated observer. To this end, we employ the coefficients $\frac{\partial x}{\partial x'}$ etc., which may be obtained directly by solving (1), and are

$$\frac{\partial x}{\partial x'} = 1 - \frac{x\Gamma}{c^2}, \quad \frac{\partial x}{\partial y'} = -\frac{y\Gamma}{c^2}, \quad \frac{\partial x}{\partial z'} = -\frac{z\Gamma}{c^2}, \quad \frac{\partial x}{\partial t'} = \frac{r\Gamma}{c};$$

$$\frac{\partial y}{\partial x'} = 0, \quad \frac{\partial y}{\partial y'} = 1, \quad \frac{\partial y}{\partial z'} = 0, \quad \frac{\partial y}{\partial t'} = 0;$$

$$\frac{\partial z}{\partial x'} = 0, \quad \frac{\partial z}{\partial y'} = 0, \quad \frac{\partial z}{\partial z'} = 1, \quad \frac{\partial z}{\partial t'} = 0;$$

$$\frac{\partial t}{\partial x'} = -\frac{x^2\Gamma}{c^2r}, \quad \frac{\partial t}{\partial y'} = -\frac{xy\Gamma}{c^2r}, \quad \frac{\partial t}{\partial z'} = -\frac{xz\Gamma}{c^2r}, \quad \frac{\partial t}{\partial t'} = 1 + \frac{x\Gamma}{c^2};$$

All the quantities here are those apparently observed by the accelerated observer, because

$$\Gamma\ (S \text{ relative to } S') = -\Gamma\ (S' \text{ relative to } S),$$

as is easily proved when the two systems instantaneously coincide and with relative velocity equal to zero.

Comparing (1) and (5), we see that the field due to a rest charge observed by an accelerated observer is exactly identical with that due to accelerated charge observed by a rest observer, provided that the quantities are relative to the observer in question.

The relative nature of radiation is now obvious and incidentally the relative nature of acceleration is indicated.

We have also investigated the properties satisfying this 'relativity transformation' and shown that the only 'force' existing in Nature is that obeying the central inverse square law and derivations therefrom.

*Note added*, March 30, by Su-Chin Kiang. The transformations discussed above possess group properties with unit Jacobian. An antisymmetrical tensor of rank 4 can therefore be introduced. The two invariants of the electromagnetic fields are $E^2 - H^2$ and $\vec{E}\cdot\vec{H}$. They represent invariants for systems in arbitrary motion. Taking the simplest case, for example, the field due to an accelerated point charge, they give $\vec{E}\cdot\vec{H} = 0$ and $E^2 - H^2$ equal to the rest Coulombian $E^2$. (5)

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## A Non-radiating Motion of a Spinning Electron

In both theories referred to in earlier communications[1], a free spin-particle travels in a suitably chosen frame of reference along a small circle. The point-charge of an electron revolving on a circle the diameter of which is of the order $\frac{\hbar}{m_e c}$, where $m_e$ is mass of an electron, with the enormous frequency of Schrödinger's *Zitterbewegung*, would radiate according to the laws of classical electrodynamics with a very high intensity. It is true that a classical model cannot be expected to give a fair account of the radiation emitted by an electron, but such a large radiation without counterpart in Nature would render any correspondence between the classical and the quantum-mechanical behaviour of an electron impossible. I noted in 1938[2] that the situation changes radically if one takes into account not only the charge of an electron but also its magnetic moment. Under suitable conditions, the radiation due to the revolving magnetic dipole (perpendicular to the plane of the circle) may cancel, approximately at least, the radiation emitted by the revolving point-charge. The argument presented in 1938 was carried through in non-relativistic approximation only, but it can be applied in the general case also, if we interpret all the quantities involved as referring to the 'rest-system of the circle'.

The argument in brief is as follows. A magnetic dipole while moving produces a transverse electric dipole. The constants of the motion may be adjusted in such a way as to make the superposition of the latter on the point-charge equivalent to the shifting of that charge from the circumference to the centre of the circle. This happens when the angular velocity of the unipole-dipole singularity is $\omega_\sigma = c/M_\sigma c$. Putting $\omega_\sigma = M_\sigma c^2/s_\sigma$, we get the condition of vanishing radiation in the form

$$\mu/s = \varepsilon/M_\sigma c. \quad . \quad . \quad . \quad (1)$$

$s$ being the electric charge of the singularity and $\mu$ the magnitude of its magnetic moment.

In the *second case*[3], $M_\sigma$ has to be put equal to the rest-mass of the electron, and thus the radiation vanishes when $\mu/s$ has just the same values as it actually has for an electron. In the *first case*, however, the constant mass is not $M_\sigma$ but $m_e$, which is connected with $M_\sigma$ by the relation $m_e = M_\sigma/\sqrt{1 - v_\sigma^2/c^2}$ and (1) becomes $\mu/s = s/m_e c\sqrt{1 - v_\sigma^2/c^2}$. Comparing this with the expression (8) of my earlier communication[1] we see that in the *first model* the radiation vanishes only for infinitesimal 'proper radii of the circle'.

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Jan. 3.

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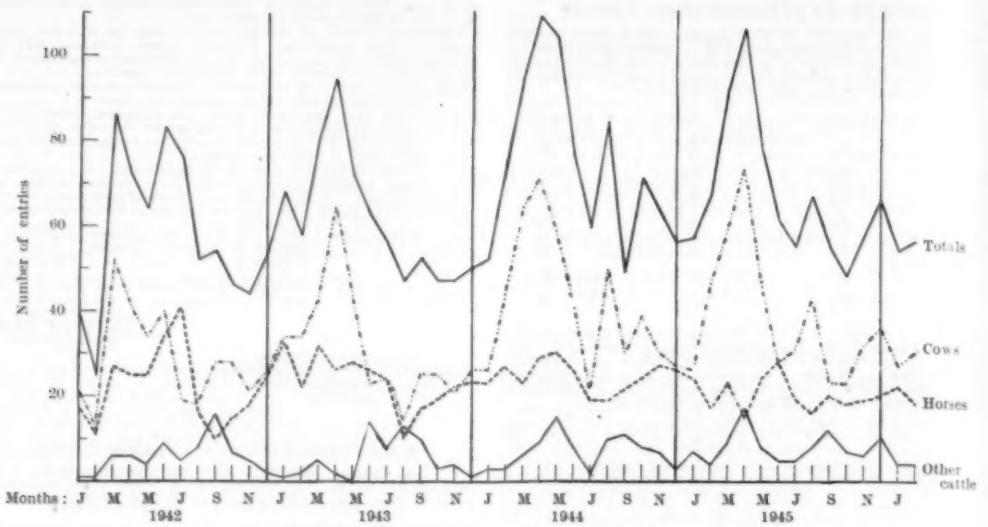
## Losses and Wastage in Farm Livestock

In the past, material for the estimation of the wastage and losses in farm livestock has been collected from the records obtained from survey farms. Another source of valuable information on the question can be obtained from the knackeries which are found in most livestock areas in Great Britain. A West Wales knackery was able to supply a full record of the intake for four years 1942–45 with particulars of the date, source and description into the following categories: cows, horses and other cattle (bulls, steers and heifers). The smaller farm animals—calves, sheep and pigs—were not collected by the knackery as they were considered too small to cover transport costs. This knackery has a collecting area of roughly twenty miles radius. The examination of the records show that a total of 3,116 animals (30 per cent of them alive) was collected during the four years. The following table gives the details of the annual intake for each year.




MONTHLY INTAKE INTO KNACKERY DURING 1942–45

| Year | Cows | Horses | Other cattle | Not described | Total |
|---|---|---|---|---|---|
| 1942 | 347 | 264 | 70 | 4 | 685 |
| 1943 | 387 | 282 | 63 | — | 732 |
| 1944 | 504 | 281 | 85 | 21 | 891 |
| 1945 | 467 | 243 | 98 | — | 808 |
| Total | 1705 | 1070 | 316 | 25 | 3116 |
| Average | 426 | 267 | 79 | 6 | 779 |

In total intake and in cows, the monthly graphs show a peak in the spring months, and for cows in particular the month of April is the worst, with a mean intake of 63 cows. The curve for horses is more level, with a slight rise during the months of greatest incidence of grass disease (May, June and July); while for 'other cattle' there is a minor peak in spring and another in early autumn.

This variation in the seasonal mortality of farm livestock as shown by the graphs is in agreement with the general observations of veterinary practitioners, and also with the well-known fact that farm animals are in their poorest condition during the late spring months.

At another knackery in a dairying district in Carmarthen, the records of intake for the short period February 24–March 16, 1946, shows a gross intake of 51 cows in 17 days.

It is now proposed to examine knackery records in this area and to prepare an atlas of the distribution of farm casualties in relation to the stocking for each parish.

It appears already from these records that this method gives valuable information on the question of wastage and losses in the larger farm animals.

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## Raman Effect in Rock-salt

IN a recent communication[1], R. S. Krishnan rejects the explanation of the Raman spectrum of rock-salt given by Miss Bradburn and myself[2]. He repeats the contention that the photomicrographs taken by Fermi and Rasetti[3] and by himself[4] represent a line spectrum. The Italian physicists themselves have interpreted their results as a continuous band, and there is no reason to doubt the opinion of such experienced observers. Krishnan's own photograph is of exactly the same type, namely, a continuous intensity maximum rising high above the average background, on which some small peaks are discernible. The latter are regarded by Krishnan as representing lines. If this were true, there are two possibilities: (1) If the lines are sharp, then the background between them should not be stronger than outside the region; as it is in fact much stronger, almost of the same intensity as the maxima of the lines, it must represent a separate phenomenon connected with the Raman effect: in this case the line-theory given by Raman is incomplete. (2) If the lines are broad so that their overlapping constitutes the raised background, then they are not lines, but maxima of continuous bands, which is our own interpretation. In both cases Krishnan ought to give the explanation of the characteristic feature. In the first case, how a monochromatic primary beam could produce scattered light which has, apart from a line spectrum, a continuous intensity distribution over the same range; in the second case, how the abnormal width of the lines can be understood.

A correct theory has to explain the raised background and the kinks as well. Our theory gives a satisfactory qualitative account of this characteristic feature. We have never claimed to have explained all details of the spectrum. For we were compelled to use simplifications and approximations to make the complicated problem tractable; for example, we have reduced the 36 bands of the exact theory to 16. It is therefore not worth while to enter into a discussion of details with Krishnan.

In the question of the "abrupt termination of the spectrum at 360 cm.$^{-1}$", we see no discrepancy, as just in this region our theoretical curve coincides perfectly with the photomicrogram. Finally, we wish to stress that the theory developed by us is nothing more than the straightforward application of the laws of (classical and quantum) mechanics, while Raman's attempts of explanation which Krishnan wishes to confirm are in contradiction to these laws.

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## A Substitute Jewel Bearing

DURING the War, the danger that New Zealand might be cut off from supplies (and the difficulty of getting any) led to considerable effort to find substitutes. The short article in *Nature*[1] on "Meter and Instrument Jewels and Pivots" reminded me of a good substitute we found for the sapphire-steel combination used in prismatic compasses. The 'jewel' was made by press-moulding a molten 'drop' of 'Pyrex' glass in a two-piece chromium-steel mould—it emerged almost a finished article with a fired surface that proved very good. The pivot was made by turning softened silver steel (Stubbs, gauge 17) by means of projection turning and then hardening, electro-cleaning, polishing, etc., and finally electroplating on the tip with chromium. The radii of the pivots and of the jewels were measured by microscope projection for the former and mirror-image formation for the latter[2].

All tests on the combination showed that the plated tips were a great improvement over the unplated—the friction of the glass 'jewel' on new pivots was about 50 per cent less; the deterioration due to wear was almost negligible after six hours continuous irregular deflexion whereas, for the unplated ones, it was on the limit allowable; rusting in damp cotton wool was resisted for a week, and the plated tips were superior on drop tests. Comparison of the whole bearing, glass plus chromium-plated pivot, with three Service compass bearings (sapphire plus steel), showed, for the wear test, that the substitute was much better than one Service model and at least equal to the other two. Time did not permit of more extended testing, but the combination was used in various compasses, and the bearings after some two years or more are still good. The interesting point is the apparent 'lubrication' produced by the chromium plating against the fired glass surface.

This work was done as part of the war work under the N.Z. Department of Scientific and Industrial Research. Details of the hand-moulding machine and the pivot treatment can be given to any who desire them. The measurements were done by Mr. Blackwell, and the mechanical work by Mr. C. Smith.

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# VERNALIZATION OF CROPS CULTIVATED IN INDIA

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IT has been previously reported[1,2] that certain wheat varieties (*I.P.* 165, *I.P.* 4 and *I.P.* 52) cultivated in India differ in their response to the vernalization process (pre-sowing cold temp. 6°–8° C. treatment) with reference to the incidence of flowering (ear-emergence) from those of their closely allied relatives of the temperate region. These varieties showed significant earliness in ear-emergence only when vernalized seeds were grown under long-day conditions, that is, when the available light period in the following photo-phase was in the range of 12 hr. or more. Any light period of short-day lengths of less than 12 hr. retarded the same. Similar results were reported by Pal and Murty[3] on Indian varieties *I.P.* 114, *I.P.* 165 and also on English winter wheats.

The varieties Cambridge Rivett, Yeoman II and Joss 4 responded to vernalization when the post-sowing long days were available either in the form of supplemented artificial light in the plains in winter or under natural lengthening days of the hills (Simla) during spring months. Sen and Chakraverty[4] have reported significant response in certain strains of cultivated wheat in higher altitudes of the Almora Hills, but the light period available to the seedlings at the subsequent photo-stage was not mentioned.

The above results have clearly brought into prominence the importance of post-sowing photo-stage, that is, the definite periods of light alternating with definite periods of darkness, in any scheme of cold temperature vernalization of winter crops. This was further confirmed by investigations on other varieties as *I.P.* 125, *I.P.* 114, *Pb.* 8*A*, *Pbc.* 591, Yeoman II and Little Joss[5].

On the other hand, the vernalization response in typical heat-loving tropical crops like jute and different strains of aus (spring) and amon (winter) paddy was found to be quite different from that of the wheat crop. Here the cold-temperature vernalization induced a delaying effect, and the effect of high-temperature vernalization (34°–35° C.) was varietal in nature, showing response towards earliness in some varieties[6]. The light period favourable for the completion of the subsequent photo-stage was found to be in the region of short-day lengths[7,8,9,10], that is, light period of 10 hr. or less alternating with dark period of 14 hr. or more. Any long-day period of 12 hr. or more tended towards the retardation in the time of ear-emergence. Investigations on two varieties of jute showed similar results[11,12]. Some of the results so far obtained on different crops have been summarized in the two tables for comparison.

The tabulated results clearly show the characteristic response of the different crops to vernalization (pre-sowing thermal treatment) as well as to post-sowing photo-periodic treatments. In winter cereals, like wheat and oat, factors found favourable for inducing significant earliness in the time of ear-emergence were cold temperature in the thermal phase and day lengths towards the region of longer days in the subsequent photo-stage. Any other combination retarded the same. The available short days of the tropics were tolerated and the varieties no doubt flowered under these conditions; but to enable the seedlings to pass their phases in shorter time and thus to induce a significant earliness which is the primary aim of vernalization experiments, a certain number of long days were found to be essential in the photo-phase, and once the photo-stage has been passed the seedlings could grow independent of the day lengths. The cold-temperature vernalization was, therefore, associated with post-sowing long-day periods.

TABLE 1. SHOWING THE INDUCED EFFECT OF PRE-SOWING THERMAL TREATMENT ON THE TIME OF EAR-EMERGENCE AS COMPARED WITH NORMAL (CONTROL). NUMBERS OF DAYS COUNTED FROM SOWING DATE. *A*—COLD TEMP. (6°–8° C.) TREATMENT FOR 21 DAYS. *B*—WARM TEMP. (34°–35° C.) TREATMENT FOR 15 DAYS. + INDICATES INDUCED EARLINESS; − INDICATES INDUCED DELAYING EFFECT

| Crops | Control | Thermal treatment | | Difference due to | |
|---|---|---|---|---|---|
| | | *A*—Cold | *B*—Warm | *A* | *B* |
| | Days | Days | Days | Days | Days |
| *A*—Wheat varieties (*Triticum vulgare*) | | | | | |
| 1. *I.P.* 165 | 58·0 | 58·0 | — | nil | — |
| 2. *I.P.* 4 | 54·0 | 52·0 | — | +2 | — |
| 3. *I.P.* 52 | 61·0 | 61·0 | — | nil | — |
| 4. *I.P.* 125 | 61·0 | 61·0 | — | nil | — |
| 5. *I.P.* 114 | 80·2 | 77·0 | — | +3·2 | — |
| 6. *Pb.* 8*A*. | 86·0 | 78·0 | — | +8·0 | — |
| 7. *Pbc.* 591 | 74·0 | 69·0 | — | +5·0 | — |
| *B*—Oat varieties (*Avena sativa*) | | | | | |
| 1. *I.P.* 1 | 82·0 | 80·0 | — | +2·0 | — |
| *C*—Paddy varieties (*Oryza sativa*) | | | | | |
| Aus—spring variety (Bengal) | | | | | |
| 1. Dharial | 87·0 | 94·2 | 83·0 | −7·2 | +4·0 |
| 2. Kataktara | 87·0 | 100·4 | 82·0 | −13·4 | +5·0 |
| Amon varieties (Winter Paddy—Bengal) | | | | | |
| 1. Bhasamanik | 125 | 129 | 125 | −4 | nil |
| 2. Latisail | 120 | 122 | 121 | −2 | −1 |
| 3. Patnai | 126 | 123 | 126 | +3 | nil |
| 4. Jhingasail | 122 | 121 | 122 | +1 | nil |
| 5. Chinsura | 125 | 127 | 107 | −2 | +18 |
| 6. BadkalamKati | 119 | — | 106 | — | +13 |
| 7. Nagra | 127 | 127 | 127 | nil | nil |
| 8. TilakKacheri | 128 | 129 | 123 | −1 | +5 |
| *D*—Jute varieties | | | | | |
| 1. *Corchorus capsularis* (*D* 154) | 116 | 120 | — | −4 | — |
| 2. *C. olitorius* (Chinsura green) | 121 | 130 | — | −9 | — |

TABLE 2. SHOWING THE INDUCED EFFECT OF POST-SOWING PHOTO-PERIODIC TREATMENT ON THE TIME OF EAR-EMERGENCE AS COMPARED WITH NORMAL (CONTROL). *A*—LONG DAYS, 17 HR. LIGHT ALTERNATING WITH 7 HR. DARK PERIOD FOR 15 DAYS. *B*—SHORT DAYS, 8 HR. LIGHT ALTERNATING WITH 16 HR. DARK PERIOD FOR 15 DAYS. + INDICATES INDUCED EARLINESS; − INDICATES INDUCED DELAYING EFFECT

| Crops | Control | Photo-periodic cycle | | Difference due to | |
|---|---|---|---|---|---|
| | | *A*—Long | *B*—Short | *A* | *B* |
| | Days | Days | Days | Days | Days |
| *A*—Wheat varieties | | | | | |
| 1. *I.P.* 165 | 54·0 | 30·4 | 72·4 | +23·6 | −28·4 |
| 2. *I.P.* 4 | 58·0 | 34·5 | 86·5 | +23·5 | −28·5 |
| 3. *I.P.* 52 | 57·5 | 36·2 | 72·3 | +21·3 | −14·8 |
| 4. *I.P.* 125 | 61·0 | 37·0 | 78·0 | +24·0 | −17·0 |
| 5. *I.P.* 114 | 77·2 | 35·2 | 97·4 | +42·0 | −20·2 |
| 6. *Pb.* 8*A* | 78·4 | 55·0 | 95·5 | +23·0 | −17·1 |
| 7. *Pbc.* 591 | 69·5 | 46·5 | 87·0 | +23·0 | −17·5 |
| *B*—Oat varieties | | | | | |
| 1. *I.P.* 1 | 82·0 | 39·0 | 96·5 | +43·0 | −14·5 |
| *C*—Paddy varieties | | | | | |
| —Aus | | | | | |
| 1. Dharial | 80·0 | 69·0 | 78·0 | +11·0 | + 2·0 |
| 2. Kataktara | 89·0 | 83·0 | 87·0 | + 6·0 | + 2·0 |
| Amon | | | | | |
| 1. Bhasamanik | 126·0 | 127·8 | 112·8 | − 1·8 | +13·2 |
| 2. Latisail | 120·8 | 126·5 | 105·3 | − 5·7 | +15·5 |
| 3. Patnai | 125·0 | 126·5 | 111·0 | − 1·5 | +14·0 |
| 4. Jhingasail | 124·5 | 127·7 | 112·5 | − 3·2 | +12·0 |
| 5. Chinsura II | 121·3 | 118·7 | 112·7 | − 2·6 | + 8·6 |
| 6. BadkalamKati | 119·0 | 115·2 | 106·0 | − 3·8 | +13·0 |
| 7. Nagra | 127·5 | 133·0 | 121·5 | − 5·5 | + 6·0 |
| 8. TilakKacheri | 126·5 | 134·0 | 120·0 | − 7·5 | + 6·5 |
| *D*—Jute varieties | | | | | |
| 1. *C. capsularis* | 116·0 | 120·0 | 69·0 | − 4 | +47 |
| 2. *C. olitorius* | 121·0 | 128·0 | 64·0 | − 7 | +57 |

On the other hand, in different varieties of paddy and jute warm temperature associated with short-day lengths were inducive to earliness, and cold temperature or longer day lengths produced retardation. Once the photo-stage was passed under short-day conditions, they also grew independent of day lengths, as was found in case of wheat seedlings. But there was a fundamental difference in their requirements of temperature and light conditions during the completion of different phases. The tropical crops like paddy and jute, therefore, differed essentially from winter wheats or other temperate crops. These fundamental differences must be considered in any scheme of vernalization. In the tropics the crops are adapted to high temperature and short-day lengths with prolonged dark periods while the reverse is the case in temperate crops. There exists a critical range of photoperiodic cycle alternating with dark periods for each type, depending upon the place of origin and the methods of adaptation it has undergone during the process of centuries of adaptation. This explains the difference in the behaviour of the crops cultivated in India with reference to the vernalization process, and further investigations are required to develop a technique suitable to the life-cycle of the Indian crops if it is to be adopted as an economic means for growing crops.


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# SEX DIFFERENTIATION IN AMPHIBIA


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THE research which is summarized below was based on the well-known investigations of Witschi, who showed that at an early stage of development the amphibian gonad consists of a cortex and medulla. At a later stage, sex differentiation is marked by an increase of cortex relative to medulla or vice versa. If the former occurs, the undifferentiated germ cells remain in the cortex and become oocytes; if the latter they tend to migrate into the medulla and become male gametes. Under normal conditions, the relative development of cortex and medulla is determined by the hereditary constitution, that is, by the balance between female- and male-determining genes born on the sex chromosomes and autosomes respectively, from interaction of which one or other of the primary sex 'realizers' is produced. A secondary sex determiner is then secreted by the cortex (cortexin), which initiates oogenesis and simultaneous regression of the medulla, or by the medulla (medullarin), which promotes spermatogenesis and inhibits further development of the cortex. Cortexin and medullarin must be considered as substances distinct from the adult sex hormones[1].

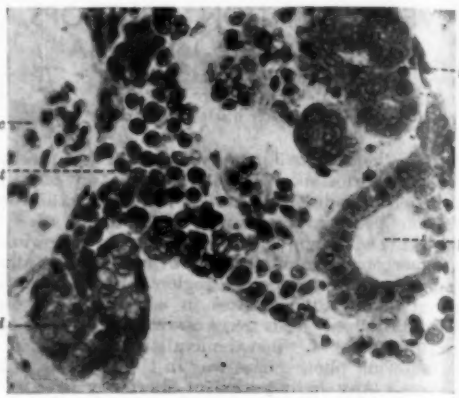


Fig. 1. TADPOLE OF *Rana agilis*, LENGTH 10 MM.
*pc*, posterior vena cava; *Wd*, Wolffian duct; *mf*, mesonephros; *int*, inter-renal tissue; *gd*, gonad. The inter-renal origin of the medullary portion of the gonad is evident.

I have studied the embryological origin of the gonad's medulla in tadpoles of several anuran Amphibia (*Rana*, *Bufo*, *Bombina*), and have found that, contrary to general belief, it does not originate from the mesonephric blastema, but from inter-renal tissue (Fig. 1)[2]. This has been confirmed experimentally by removal of the whole mesonephric rudiment at an early stage, leaving the inter-renal intact. Even under these conditions, the developing gonads contain medullary tissue[3].

There is thus an intimate histogenetic relationship between the inter-renal cells and the medullary tissue of the gonad. This fact fits in with the well-known chemical similarity between the hormones of the suprarenal cortex and the sex hormone of the adult male. The supra-renal cortex is formed from those inter-renal cells which do not participate in the formation of the gonad, whereas the male sex hormone may be produced by the interstitial cells of the testis, which are derived from the medulla. We are also led to suspect that medullarin has a steroid structure similar to that of the sex and supra-renal cortical hormones of the adult.

I have done some detailed research on the so-called undifferentiated races of Amphibia. It appears that in these races the primary female realizer at first predominates even in genotypical males, and the gonads become for a time ovary-like before being transformed into testes (Witschi). This is correlated with oogenesis in the cortex, which proceeds as far as the prophase of the first maturation division. It is accompanied by regression of the medullary tissue, which is due to cessation of proliferation from the inter-renal blastema, perhaps under the inhibitory influence of cortexin. The simultaneous enlargement of the cortex causes the medulla to be reduced to a single layer of cells lining the ovarian sacs[4].

The subsequent sexual inversion of these gonads starts with a renewed proliferation of the medullary tissue which fills the central cavities of the ovary-like gonads. In tadpoles of *Rana agilis* I was able to establish that this new medullary tissue is also derived from the inter-renal blastema. The renewed medullary proliferation must be due to the primary male 'realizer', which now becomes dominant. Contrary to previous belief, not only the primary oogonia but also the secondary oogonia and those

oocytes which have not entered the prophase of the first maturative division are sexually bipotent. Through the stimulating action of medullarin, these cells leave the cortical region of the gonad and are attracted into the newly formed medullary tissue, where they become spermatogonia. The oocytes which had already entered the prophase of the first maturative division at the time of the sexual inversion do not leave the cortical region, and the inhibitory action of medullarin causes their complete degeneration. Before degenerating, however, those oocytes which have not passed the pachytene stage may, under the combined influence of cortexin and medullarin, show cytological aberrations comparable with changes which normally occur in spermatocytes[5]. Similar inter-sexual germ cells have been described in *Rana esculenta* by Galgano and in *Rana catesbiana* by Swingle[6].

I later examined the effects on amphibian tadpoles of the principal sex and suprarenal cortical hormones of the adult. Previous research had shown that testosterone will masculinize the gonads of all individuals (Gallien, Witschi), whereas œstradiol in small doses has a feminizing and in large doses a masculinizing effect (Padoa). More recent work of Padoa has also demonstrated the masculinizing action of progesterone, and the feminizing action of one of the suprarenal cortical hormones (desoxycorticosterone)[7].

My experiments to date on tadpoles of *Rana agilis* have shown that in influencing the sexual differentiation of the gonad each of the above hormones acts through a different mechanism. The follicular hormone (œstradiol) in small doses feminizes the rudimentary gonad by stimulating growth of the cortex. On the other hand, the suprarenal cortical hormone produces the same effect by inhibition of medullary proliferation. If the treatment is started early enough ovaries are formed which are permanently and completely devoid of medullary tissue[8]. The testicular hormone (testosterone) masculinizes the gonad by direct stimulation of the medullary tissue, whereas the hormone of the corpus luteum (progesterone) exerts the same effect indirectly by inhibiting the differentiation of oocytes in the cortex. Thus with progesterone the ovaries develop normally to the stage at which the cortex contains primary and secondary oogonia. The subsequent gradual masculinization of the gonads is associated with partial or complete absence of oocytes and with failure to regress on the part of the medulla, which therefore takes control (Fig. 2). I am not yet able to explain the mechanism of masculinization by large doses of œstradiol, which was discovered by Padoa.

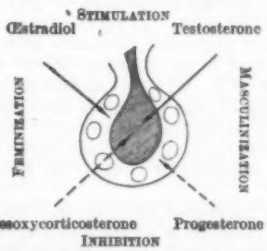


Fig. 2. SCHEME TO REPRESENT THE EXPERIMENTAL ACTION OF HORMONES ON THE SEXUAL DIFFERENTIATION OF THE GONAD. THE SHADED PORTION REPRESENTS THE MEDULLA, THE EXTERNAL WHITE LAYER THE CORTEX; THE CIRCLES CONTAINED IN THE CORTEX INDICATE GERM CELLS. THE CONTINUOUS ARROWS INDICATE STIMULATION THE INTERRUPTED ARROWS INHIBITION

The main point of interest is that the actions of the above substances are remarkably similar to those normally attributed to the sex 'realizers' and inductors. Thus œstradiol in small doses and testosterone act like the primary female and male realizers respectively, whereas desoxycorticosterone and progesterone imitate the inhibitory action of cortexin and medullarin. This leads me to suspect that the sex realizers and inductors are sterols like the sex and suprarenal cortical hormones of the adult.

I intend continuing this work and extending it to the Amniota, which resemble the Amphibia in the mode of development of the gonad. Preliminary observations have shown that in the chick embryo, as in the Amphibia, the medullary tissue of the gonad is derived from the inter-renal blastema[9].

[1] Witschi, E., "Handb. der Vererb", **2** (1929). Witschi, E. (in Allen's "Sex and Internal Secretions") (Baltimore 1934). Witschi, E., *Scientia*, **68**, 146 (1940).
[2] Vannini, E., *Mem. R. Accad. d'Italia*, **13**, 731 (1942). Vannini, E., and Busetto, I., *Atti R. Ist. Veneto Sci. Lett.*, **104** (1945).
[3] Vannini, E., *Atti R. Ist. Veneto Sci. Lett.*, **104**, 55 (1945).
[4] Vannini, E., *Atti R. Ist. Veneto Sci. Lett.*, **102**, 7 (1943).
[5] Vannini, E., *Arch. Zool. Ital.*, **30**, 363 (1942).
[6] Galgano, M., *Arch. Ital. Anat. Embry.*, **37**, 1 (1936).
[7] Padoa, E., *Pub. Staz. Zool. Napoli*, **19**, 185 (1943).
[8] Vannini, E., *Atti R. Ist. Veneto Sci. Lett.*, **103**, 535 (1944).
[9] Vannini, E., *Mem. R. Accad. d'Italia*, **14**, 493 (1943).

## PUBLIC HEALTH AND EXPERIMENTAL MEDICAL RESEARCH

A PRINCIPAL feature of the 1945 issue of *The Fight against Disease*, the organ of the Research Defence Society, is the fourteenth Stephen Paget Lecture, given by Sir William Savage, entitled "Public Health and its Debt to Experimental Medical Research". Public health, said Sir William, is concerned with all measures which operate to promote or to maintain the health of the community, the direct treatment of disease being usually outside its scope. It is, therefore, not a science, but includes the application of many sciences to all its purposes. Because the development of many sciences has depended upon research which involved the use of experiments upon animals, developments in public health during the last fifty years have also depended upon this use of experimental animals. We now have, speaking generally, sufficient knowledge to control most of the infectious diseases, but we cannot always apply that knowledge, because its application would be prevented by interference with the liberty of the subject, the reluctance of many people to respond to preventive measures or to endure the inconveniences involved.

Sir William discusses, as examples of public health practice, the control of the enteric fevers, diphtheria and whooping cough. During the years 1871–75, the deaths due to enteric fevers were 371 per million; in 1939–40 they were 3 per million. This striking evidence of the application of the results of scientific research may be contrasted with the fact that, until recently, there has been a marked, but not a conspicuous, decline in the mortality due to diphtheria. During 1856–65 the deaths due to diphtheria were 247 per million; during 1936–40 they were 62 per million. The control of this disease falls into three stages. The first stage was the recognition of the disease as a clinical entity; the second stage began with the introduction in 1894 of specific treatment of

the disease with diphtheric antitoxin, which dramatically reduced the mortality, but did not reduce the prevalence of the disease; the third stage began with the introduction of specific immunization, which was introduced in 1926 in Canada and the United States and was only gradually adopted elsewhere. In Britain it has been widely practised only during the Second World War. The figures given by Sir William clearly show the value of this immunization and reinforce the campaign of the British Ministry of Health to popularize it. Another striking example of its value is the statement made by Dr. Stowman, chief of the Epidemiological Service of the United Nations Relief and Rehabilitation Administration (*Brit. Med. J.*, 742, May 26; 1945), a statement which Sir William was no doubt not in a position to mention, that diphtheria was the most prevalent epidemic disease in Europe during the recent War. Some 15,000 people died of it in Germany alone, and in Norway and the Netherlands its incidence was, in 1943, fourteen times or more greater than it normally is. The number of carriers of the disease also increased enormously. Diphtheria began, indeed, to rival tuberculosis as the principal cause of death. In England, however, and Hungary, immunization has actually reduced the incidence.

Whooping cough, the third example taken by Sir William, is a disease which has only been notifiable during the last few years. There is little evidence of its decline. Ninety per cent of the deaths due to it occur in the age-group less than five, and the deaths per million at all ages are still considerable (475 per million in 1941). Whooping cough is, however, difficult to diagnose in its early stages when infection may be spread, and general immunization is, in the present state of our knowledge, probably not worth while. Sir William thinks, however, that immunization of all children less than five, and especially of those less than two, would eliminate nearly all the deaths at these ages and also the after-effects.

Considering environmental improvements, Sir William discusses the great progress that has been made. Taking the control of human tuberculosis as an example, he states that the decline of the mortality due to the measures taken against it "is perhaps the most striking statistical fact in relation to public health".

Among the measures taken against this disease is the practice of mass miniature radiography of civilians, which is the subject of the Medical Research Council's Special Report upon it (Special Report Series, No. 251; 1945. H.M. Stationery Office. 3*s*. net). This report is a guide to administration and to the technique of a mobile apparatus which uses 35 mm. films, and it gives the valuable results obtained. Messrs. Watson and Sons (Electro-Medical) Ltd. also issue a brochure on the use of mass miniature radiographical apparatus. Dr. W. Pointon Dick (*Brit. Med. J.*, 568, Oct. 27; 1945) concludes, as a result of mass miniature radiography of factory groups in Middlesex, that there are probably 3,000 undiagnosed people in that county who need treatment, half of them being without symptoms. Dr. J. F. Brailsford (*Lancet*, 808, Dec. 22; 1945), in a valuable discussion of mass radiography, testifies to its value.

The work that has been done on the welfare of the mother and child is also dealt with by Sir William Savage. His discussion of the importance of food supplies is marked by the reminder that, although the control of human tuberculosis is advancing, 40 per cent of the milk cattle of Britain are tuberculous, which means that, although only about 1 per cent of these cattle are at any one time excreting tubercle bacilli into the milk, even this rate of contamination involves an infection of the milk supply of 5–7 per cent. Sir William has calculated that in 1929 about 2,000 deaths in England and Wales, mostly deaths of children, were due to the bovine type of tubercle bacillus, and he thinks that the figure is nowadays about 1,500–1,600.

Sir William concludes with a section on the importance of adequate nutrition and defines three phases of the development of preventive medicine. The first phase was the great drive, pioneered by Chadwick and Simon, towards environmental improvements. The second phase was the attack upon special diseases, such as tuberculosis and venereal diseases. Our widened knowledge permits us to go forward with the third phase, which aims at the prevention of deviations from health, whatever their cause may be.

G. LAPAGE

## CHEMICAL IMPREGNATION OF TREES AND POLES FOR WOOD PRESERVATION

UNDER this title, in Circular No. 717, B. H. Wilford, entomologist of the United States Department of Agriculture, Research Investigations (Supt. of Documents, U.S. Gov. Printing Office, Washington 25, D.C.), discusses methods of preserving the life of trees and poles used for fencing and other agricultural purposes.

The United States are not alone among the countries which, through the centuries, have experimented with the object of finding some cheap process to be used with the object of preserving or protecting wood from decay or attacks by insects and fungal pests. As the author says, there is a general and constant need in the United States for cheap, durable woods for fence posts, rural utility poles and rustic construction "presumably including wooden buildings". Suitable woods of natural durability are relatively scarce, whereas perfectly useful timbers are plentiful but not durable". Considerable investigation work with the object of pointing out this disability has been carried out in the United States, Canada, India and elsewhere. Simple methods and inexpensive materials were the main objects of the research. The investigations were carried out to find treating methods and chemicals that would be: (1) destructive or repellent to injurious insects and fungi over a reasonably long time; (2) harmless to man and other warm-blooded animals; (3) easily applied for ready absorption and even distribution of the chemicals within the tree or pole; (4) inexpensive with respect to the chemicals and materials used, and the labour required; (5) non-injurious to the treated wood, that is, containing nothing that will stain the wood or weaken it structurally; and (6) non-corrosive to hard wear.

Chemical impregnation of green trees and poles by sap-stream methods is an old idea that has been used to advantage for centuries. It had, however, fallen into abeyance, as it is not applicable to commercial use. Investigations made between 1930 and 1940 in North Carolina and South Carolina with a number of methods, 58 chemicals and chemical combinations

and 1,639 trees and 188 poles and at different seasons of the year, have shown that farmers and other users of wood-lot trees can increase the durability of fence posts and so forth with little expense and labour. Stepping and capping are simple operations, and the circular furnishes full information with useful photographs on how to proceed.

## INTERNATIONAL VETERINARY AND LIVESTOCK SECRETARIAT FOR THE FAR EAST

A CONFERENCE of Far Eastern Member Governments convened by the United Nations Relief and Rehabilitation Administration was held in Sydney, Australia, during December 1945. A wide range of problems was discussed, and as a result an UNRRA (South-West Pacific Area) International Veterinary and Livestock Secretariat for the Far East was set up.

The following were represented at the Conference: the British and American Far Eastern Commands, the United States of America, Australia, New Zealand, India, Netherlands Indies, China, and the Philippines. The executive officer of the Secretariat is Major William Granger, c/o UNRRA, 52 William Street, Sydney, New South Wales.

At the conference it was emphasized that the rehabilitation of war-ravaged countries must include the restoration of their livestock industries, livestock being essential for the supply of food and also for clothing, transport and agriculture. In certain of the far eastern countries the livestock population has been greatly reduced as a result of the War. It is essential to safeguard them against the ravages of epizootic disease, and in the earlier post-war period there are special dangers in this respect, the conditions which lead to the introduction and spread of certain diseases being operative on account of the prevailing circumstances. It will be necessary for certain countries to import livestock and, unless stringent precautions are taken to ensure that epizootic diseases are not introduced by such livestock and that the animals are protected against such disease after their arrival, the consequences might be serious. Furthermore, steps must be taken to ensure that malnutrition and inefficient breeding practices do not take a toll on animal health.

It is the intention that the member countries of the International Veterinary and Livestock Secretariat will supply check lists of communicable diseases of livestock in their territories, with indications as to their prevalence and distribution. New occurrences of scheduled diseases will be notified by cable. The Secretariat will prepare monthly statistical bulletins of this information and will work in liaison with the Office International des Epizooties in Paris. Information will be pooled and distributed concerning the nature of veterinary organisations in force in the several countries and of the education and training of the staffs. There will be a general information service concerning aspects of livestock industries. Systems of health certification for animal traffic will be arranged, and it is anticipated that this will be extended to certification as to genital soundness in the case of breeding stock.

Information relating to biological products will be provided, attention being given to methods of manufacture and standardization and control. Details will be provided about methods of inspection and certification of meat and meat products and of animal products such as dairy produce, eggs, hides and skins and hair and wool intended for export, member countries being encouraged, where this is not already done, to place inspection and control of such products under veterinary supervision.

Exchanges will be facilitated of administrative, research and other veterinary and livestock workers between member countries, and postgraduate educational facilities will be provided. Where necessary, in emergency, arrangements will be made for veterinary staffs to be sent on loan from one member country to another.

The livestock requirements of the several territories will be assessed and their resources of potential exports, also their resources in personnel, equipment and fodder needed for the use and care of imported livestock in recipient countries.

It is anticipated that ultimately the Secretariat may develop into a Far Eastern Pacific Branch of a comprehensive world organisation under the control of the United Nations Organisation, along with the Office International des Epizooties. Countries not members of the United Nations Relief and Rehabilitation Administration (South-West Pacific Area) that have territories bordering on the Pacific Area will be invited to co-operate in, and support the work of, the Secretariat.

Special attention will be paid to the presence in various countries of animals particularly adapted to tropical conditions or having resistance to disease, with the aim of utilizing them in the course of building up the livestock populations.

Full details of the Conference and of the circumstances which led to its convocation are given in a report issued from the office of the Secretariat*. In addition, there is matter which takes up more than half the extent of the report, concerning League of Nations publications of 1928–35 and of a Commonwealth of Australia, Department of Health Service publication of 1935, containing information regarding subjects that fall within the scope of this new organisation.

* United Nations Relief and Rehabilitation Administration, South-west Pacific Area. Proceedings of Conference of Veterinary Representatives of Far Eastern Member Governments of UNRRA and of the Military Commands, held at 52 William Street, Sydney, Australia, on 14th, 15th and 17th December 1945. Pp. 82. (52 William Street, Sydney).

## FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

### Tuesday, June 18

ROYAL ANTHROPOLOGICAL INSTITUTE (joint meeting with the INTERNATIONAL AFRICAN INSTITUTE, at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. E. E. Evans-Pritchard: "The Sanusi of Cyrenaica".

### Wednesday, June 19

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

CHALLENGER SOCIETY (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 5.45 p.m.—Dr. S. M. Marshall and Dr. A. P. Orr: "Agar from British Seaweeds".

BRITISH PSYCHO-ANALYTICAL SOCIETY (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 8 p.m.—Prof. E. D. Adrian: "The Physical and the Mental Sources of Behaviour" (First Annual Ernest Jones Lecture).

### Thursday, June 20

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 3 p.m.—Mr. T. W. Chaundy: "The Arithmetic Minima of Positive Quadratic Forms".

CHADWICK PUBLIC LECTURE (at the Chelsea Physic Garden, Swan Walk, London, S.W.3), at 4 p.m.—Dr. Ellen M. Delf: "Plants in the Service of Mankind".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. Wilder Penfield, F.R.S.: "Some Observations on the Cerebral Cortex of Man" (Ferrier Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Thirty-ninth Annual General Meeting; at 8 p.m.—Brigadier N. Hamilton Fairley, F.R.S.: "Researches on Paludrine in Malaria".

### Friday, June 21

SOCIETY OF CHEMICAL INDUSTRY (joint meeting of the MANCHESTER SECTION, the PLASTICS GROUP, and other scientific and technical societies, in the Lecture Theatre, Central Library, St. Peter's Square, Manchester), at 6.30 p.m.—Prof. H. Mark: "Molecular Structure and Mechanical Properties of High Polymers".

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### Monday, June 17—Monday, July 8

ROYAL SOCIETY'S EMPIRE SCIENTIFIC CONFERENCE.

**Monday, June 17**

At 11 a.m. (in the Senate House of the University of London).—Opening of the Conference by H.M. the King.

**Tuesday, June 18—Thursday, June 20**

In London.

**Saturday, June 22—Friday, June 28**

In Cambridge.

**Monday, July 1—Thursday, July 4**

In Oxford.

**Saturday, July 6—Monday, July 8**

In London.

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## APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN MATHEMATICS—The Principal, Derby Technical College, Normanton Road, Derby (June 21).

SENIOR ASSISTANT FOR METALLURGY at the Coventry Technical College—The Director of Education, Education Offices, Coventry (June 22).

LECTURER (woman) IN HORTICULTURE—The Principal, Kent Horticultural Institute, Swanley, Kent (June 22).

QUALIFIED CHEMIST to teach analytical and control work to senior students in the Department of Leather Manufacture of the Northampton College of Technology—The Chief Education Officer, Springfield, Cliftonville, Northampton (June 22).

ASSISTANT LECTURER IN MATHEMATICS—The Secretary and Registrar, The University, Bristol (June 22).

ASSISTANT LECTURER IN CIVIL ENGINEERING, an ASSISTANT LECTURER IN MECHANICAL ENGINEERING, and an ASSISTANT LECTURER whose duties will be divided between the Departments of Mathematics and Engineering—The Registrar, The University, Manchester 13 (June 24).

LECTURER (Grade II) and an ASSISTANT LECTURER (Grade III) IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Secretary and Registrar, The University, Bristol (June 25).

JUNIOR RESEARCH WORKER AND PART-TIME DEMONSTRATOR IN THE DEPARTMENT OF ZOOLOGY—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (June 25).

ASSISTANT LECTURERS IN MATHEMATICS, PHYSICS, GEOLOGY, BOTANY, METALLURGY and ENGINEERING, and RESEARCH DEMONSTRATORS IN PHYSICS, CHEMISTRY, GEOLOGY and GEOGRAPHY, BIOLOGY, and METALLURGY—The Registrar, University College, Singleton Park, Swansea (June 26).

STATISTICIAN attached to the DEPARTMENT OF MATHEMATICS, and ASSISTANT LECTURERS IN BOTANY (with special qualifications in Mycology and Plant Pathology), CHEMISTRY, GEOGRAPHY (with special qualifications in Climatology and Geomorphology), MATHEMATICS (preferably in Pure Mathematics), PHYSICS (preferably with experience in Radar or Radium Therapy techniques), and ZOOLOGY—The Registrar, University College, Hull (June 29).

HEAD OF THE DEPARTMENT OF TECHNOLOGY—The Principal, Watford Technical and Art Institute, Queen's Road, Watford (June 29).

LECTURER (Grade II), and an ASSISTANT LECTURER (Grade III), IN THE DEPARTMENT OF PHILOSOPHY—The Registrar, The University, Liverpool (June 30).

SENIOR ASSISTANT CURATOR—The Curator and Librarian, Borough Museum, Maidstone (June 30).

DEMONSTRATOR IN CHEMICAL PATHOLOGY—The Registrar, The University, Leeds 2 (June 30).

PROFESSOR OF INDUSTRIAL CHEMISTRY AND DIRECTOR OF THE INDUSTRIAL CHEMISTRY INSTITUTE, PROFESSOR OF PHYSICS, PROFESSOR OF PURE MATHEMATICS, VISITING PROFESSOR OF ENTOMOLOGY, VISITING PROFESSOR OF PLANT PHYSIOLOGY, ASSISTANT PROFESSOR OF APPLIED MATHEMATICS, ASSISTANT PROFESSOR OF BOTANY, ASSISTANT PROFESSOR OF PHYSICAL CHEMISTRY in the Industrial Chemistry Institute, ASSISTANT PROFESSOR OF ORGANIC CHEMISTRY in the Industrial Chemistry Institute, and LECTURERS (8) for PURE MATHEMATICS, APPLIED MATHEMATICS, ZOOLOGY, MYCOLOGY, EXPERIMENTAL PHYSICS, INORGANIC CHEMISTRY, GEOLOGY (one for Stratigraphy and one for Mineralogy), at the Farouk I University, Alexandria—The Director, Egyptian Education Office, 4 Chesterfield Gardens, Park Lane, London, W.1 (June 30).

LECTURER (full-time) IN REFRIGERATION in the Department of Mechanical Engineering—The Principal, Borough Polytechnic, Borough Road, London, S.E.1 (July 1).

LECTURER IN MATHEMATICS—The Registrar, Trinity College, Dublin (July 1).

LECTURER IN ANATOMY—The Secretary, The University, Aberdeen (July 11).

SENIOR LECTURER (Grade I) IN THE DEPARTMENT OF MATHEMATICS, Division of Statistics—The Registrar, The University, Liverpool (July 31).

SENIOR MEMBER of staff with good academic qualifications and research experience in the application of Botany or Plant Physiology to Horticultural or Plantation Crops (at home or abroad)—The Secretary, East Malling Research Station, East Malling, Kent (October 31).

LECTURER IN MATHEMATICS, and a LECTURER IN PHYSICS—The Principal, Sir John Cass Technical Institute, Jewry Street, London, E.C.3.

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## REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

### Great Britain and Ireland

City and County of Bristol. Annual Report of the Public Libraries Committee, 1944–1945. Pp. 32 + 4 plates. (Bristol: Central Library, 1945.) [1812

Proceedings of the Royal Society of Edinburgh, Section B (Biology). Vol. 62, Part 2, No. 20: Inheritance of Resistance to Blight (*Phytophthora infestans*) in Potatoes; Unbalanced Segregations. By Dr. William Black. Pp. 171–181. (Edinburgh and London: Oliver and Boyd, 1945.) 1s. 9d. [1812

Liverpool Observatory and Tidal Institute. Centenary Report and Annual Reports (1940–1945). Pp. 28 + 6 plates. (Liverpool: Liverpool Observatory, 1945.) [1812

Agricultural Research Institute of Northern Ireland. Eighteenth Annual Report, 1944–45. Pp. 30. (Hillsborough, Co. Down: Agricultural Research Institute of Northern Ireland, 1945.) [1812

British Council. Report for 1944–1945. Pp. 182 + 12 plates. (London: British Council, 1945.) [1812

British Council: Science Department. Outline of Activities. Pp. 23. (London: British Council, 1945.) [1812

Geological Survey of Great Britain: Scotland. Wartime Pamphlet No. 44: Scottish Sources of Alkali Feldspar. By Dr. T. Robertson. Pp. 37. (London: Geological Survey and Museum, 1945.) 1s. 9d. [1812

Ministry of Health. Rates and Rateable Values in England and Wales, 1944–45, with certain particulars regarding the Rates levied in the Years 1939–40 and 1943–44. Pp. 54. (London: H.M. Stationery Office, 1945.) [1812

### Other Countries

Indian Forest Leaflets. No. 83: The Efficiency of Enumerations, 1: The Problem. By Dr. A. L. Griffith. Pp. iii+6. 4 annas. No. 84: The Efficiency of Enumerations, 2: Madras Tropical Wet Evergreen Forest; 3: Typical Calculations. By Dr. A. L. Griffith. Pp. iv+21. 8 annas. (Dehra Dun: Forest Research Institute, 1945.) [3110

Government of Travancore. Administration Report of the Government Museum, 1119 M.E. Pp. 6. (Trivandrum: Government Press, 1945.) [3110

Commonwealth of Australia: Council for Scientific and Industrial Research. Bulletin No. 185: Studies on the Mitchell Grass Association in South-Western Queensland, 2: The Effect of Grazing on the Mitchell Grass Pasture. By R. Roe and G. H. Allen. Pp. 27. (Melbourne: Government Printer, 1945.) [3110

Nutrition in Jamaica. Report by the Nutrition Committee of the British Medical Association, Jamaica Branch. Pp. 35. (Kingston: Government Printer, 1945.) 1s. [3110

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